DOCUMENT RESUME

ED 046 750 SE 010 673

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TITLE	Syllabus for an Associate Degree Program in Applied Marine Biology and Oceanography.
INSTITUTION	Southern Maine Vocational Technical Inst., South Portland.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	70
NOTE	120p.; Some pages have marginal legibility
EDRS PRICE	EDRS Price MF-$0.65 HC Not Available from EDRS.
DESCRIPTORS	*College Science, *Course Content, Courses, Curriculum, Earth Science, Environmental Education, *Oceanology, *Program Descriptions, *Technical Education

ABSTRACT

Included is a detailed outline of the content of each course required or offered as an elective in the associate degree program. With an 18 or 19 unit load each semester the program requires two years, and includes 64 hours at sea every semester. In addition to chemistry, physics, biology, and oceanography courses, there is a required course in each of these subjects: English composition, mathematics, American literature, computer mathematics, economics, political science, and sociology. Appendices include sample tests, sample experiments, lists of audiovisual materials, publications, a list of faculty, a bibliography, and photographs of activities. [Not available in hard copy due to marginal legibility of original document.] (PR)

SYLLABUS FOR AN ASSOCIATE DEGREE PROGRAM IN APPLIED MARINE BIOLOGY AND OCEANOGRAPHY

SEA GRANT PROGRAM (GRANT NO. GH-35)

SYLLABUS FOR AN ASSOCIATE DEGREE PROGRAM

IN

APPLIED MARINE BIOLOGY AND OCEANOGRAPHY

Prepared by
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NATIONAL SCIENCE FOUNDATION
SEA GRANT PROJECT GH-35
Appropriation No. 4624-8
1970

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INTRODUCTION

Southern Maine Vocational Technical Institute, has part of the North Atlantic Ocean as the eastern boundary of the campus. This location offers such varied habitat as sandy beaches, mud flats, rocky pools and beautiful Casco Bay, which has provided us with an excellent opportunity to pursue a teaching program in marine science since 1958.

Recently, with funding from the Sea Grant Program of the National Science Foundation, we have established a separate program in Applied Marine Biology and Oceanography. This syllabus has been prepared in response to queries from high school instructors interested in oceanography, maritime oriented colleges, marine industries, and other four-year schools to which our graduates can make application for advance degrees. It is also expected that this syllabus will serve as a guide to schools interested in planning a similar program. Since this outline will be revised and rearranged by the teacher, based on his own experiences, suggestions are welcome.

THE SYLLABUS

This syllabus is intended to provide a wide background to the technicians in Applied Marine Biology and Oceanography. Students in the first semester receive the fundamentals of biology and oceanography along with other related subjects. In succeeding semesters, subjects in biology and oceanography compliment and build directly on the first semester. During the last semester, a variety of electives are offered and students may choose to concentrate on a subject of special interest. A total of 64 hours is spent at sea every semester.

Graduates of this program can expect to find employment in many areas of marine science. Each area may require somewhat different abilities and different specialized knowledge for a successful career. Most of these differences will be learned by continued study on the job. The following is a partial list of jobs open to these technicians.

Oceanographic Laboratory Technicians
Fisheries Technicians
Biological Technicians
Hydrographic Survey Technicians
Applied Research Technicians
Oceanographic Instrumentation Technicians
Industrial & Marine Laboratory Technicians

TEACHING STAFF

For a successful technical education program, it is important that the faculty understands the goals and the philosophy that characterize their area of specialization. Programs such as this one requires that the teacher have special abilities based on knowledge of the subject and hopefully, practical experience in the field.

All instructors should be oriented in the requirements for study in the area of marine science so that they may use appropriate examples or subject matter as supporting material in the teaching of their respective courses. For example, a teacher teaching physics, chemistry, or mathematics, should emphasize and illustrate how the principles are applied to the study of the marine environment. Teachers with an appropriate background are more likely to understand the objectives of the program, and bring the enthusiasm that will help immeasurably in effective development of meaningful studies.

STUDENT SELECTION

A student expecting to enter the Applied Marine Biology and Oceanography field must have a strong desire to work out-of-doors and aboard ship. He should be prepared both mentally and physically for the sometime rigorous demands that will face him. He should be interested in working closely with others as a team member. He should obtain a high school diploma and should be advised to take at least two years of Algebra, one year of Chemistry, Biology, Physics, or the equivalent. Acceptable GATB (General Aptitude Test Battery) and SAT (Scholastic Aptitude Test) scores and the Mathematics Level I and English Achievement Scores must also be presented.

ACKNOWLEDGMENTS

Every member of this department as well as the Southern Maine Vocational Technical Institute faculty members involved in teaching related subjects assisted in preparing this report and without their help, it could not have been done.

APPLIED MARINE BIOLOGY AND OCEANOGRAPHY

Department Code: AMBO

ASSOCIATE DEGREE PROGRAM

First Semester

Course Number	Subject	Credits
Eng. 111	English Composition	3
Mat. 111	Mathematics	4
Chm. 111	Chemistry	4
Bio. 111	Biology	4
Oco. 111	Elements of Oceanography	4
		19

Second Semester

Eng. 112	American Literature	3
Phy. 112	Physics	4
Mat. 132	Computer Mathematics	3
Oco. 112	Instrumentation and Methods in Oceanography	4
Zoo. 112	Invertebrate Zoology	4
		18

Third Semester

Eco. 201	Economics	3
Phy. 113	Physics II	4
Nav. 21	Survey of Navigation	3
Bio. 211	Field Biology (Ecology)	4
Oco. 211	Chemical Oceanography	4
		18

Fourth Semester

Ssc. 204	Political Science	3
Ssc. 202	Sociology	3
Bio. 222	Microbiology	4
Oco. 21	Physical and Geological Oceanography	4
	Elective	4
		18

Electives

Bio. 242	Planktology	4
Bio. 244	Micr[illegible]technique	4
Bio. 246	Marine Botany	4
Bio. 248	Fishery Science	4

Course Title: English Composition

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: Four Years High School English

Course Description and Objectives:

The purpose of this course is to provide practice in writing with emphasis on mechanics and organization. Work in composition and reading in technical periodicals culminates in the preparation of a formal technical report on a subject in the student's major field.

Major Divisions:

I. Review of Mechanics
II. Logic
III. Exposition
IV. The Technical Report
V. Letters of Application

Outline of Instruction:

I. Review of Mechanics
   A. Spelling
   B. Punctuation
   C. Sentence Structure
   D. Paragraph Organization

II. Logic
   A. Fallacies
   B. Propaganda Devices

III. Exposition
   A. Description
   B. Narration
   C. Analysis
   D. Definition
   E. Argument

IV. The Technical Report
   A. Note Taking
   B. Outline
   C. Rough Draft
   D. Bibliography
   E. Format

V. Letters of Application
   A. Letter Requesting Permission for References
   B. Data Sheet
   C. Letter of Application

Text and References:

Hodges and Whitten, Harbrace College Handbook

Lee and Moynihan, Using Prose

The New York Times
Technical Periodicals

Course Title: Mathematics

Hours Required: Class, 4 hours; Laboratory, 0 hours

Prerequisites: Mathematics, 1 Year High School

Course Description and Objectives:

The course is designed to provide the necessary background in Algebra and Trigonometry for a sound mathematical background for the technician. The course is solution oriented with applications in applied engineering.

Major Divisions:

I. Algebra
II. Trigonometry
III. Analytic Geometry

Outline of Instruction:

I. Algebra
   A. Fundamental Concepts and Operations
   B. Functions and Graphs
   C. Linear Equations and Determinants
   D. Factoring and Fractions
   E. Quadratic Equations
   F. Exponents and Radicals
   G. The J-Operator
   H. Logarithms
   I. Systems of Equations
   J. Theory of Equations

II. Trigonometry
   A. The Trigonometric Functions
   B. Trigonometric Functions of any Angle or Number
   C. Vectors and Triangles
   D. Graphs of Trigonometric Functions
   E. Properties of the Trigonometric Functions
   F. The Inverse Trigonometric Functions

III. Analytic Geometry
   A. Basic
   B. The Straight Line
   C. The Circle
   D. The Parabola
   E. The Hyperbola
   F. The Ellipse

G. Translation of Axis
H. The Second-Degree Equation

Text and References:

Washington, Basic Technical Mathematics

Course Title: Chemistry

Hours Required: Lecture, 3 hours; laboratory, 2 hours

Prerequisites: High School Chemistry

Course Description and Objectives:

This course will offer an accelerated review of general chemistry placing particular emphasis on the principles of chemistry and laboratory apparatus. Although the approach will be mostly qualitative, the door will be open to analytical methods common to Industry, particularly the Marine oriented one.

Major Divisions:

I. Introduction
II. Nature of Matter
III. Stoichiometry
IV. States of Matter
V. Solutions
VI. Acids-Base Relationships
VII. Element Properties and Relationships
VIII. Organic Chemistry

Outline of Instruction:

I. Introduction
   A. Metric System
   B. Mathmatics of Chemistry

II. Nature of Matter
   A. Atomic mass
   B. Gram atoms
   C. Periodic table
   D. Electronic configurations
   E. Chemical bonds
      1. Ionic and covalent bonds
      2. Polarity
      3. Valence
      4. Electronegativity

III. Stoichiometry
   A. Formulas
      1. Empirical
      2. Molecular
   B. Formula mass
   C. Mole concept

D. Oxidation-Reduction
E. Gram-Equivalents
F. Heats of reaction

IV. States of Matter
A. Gases
1. Properties of gases
2. Pressure, temperature, volume relationships
3. Kinetic theory
4. Van der Waals forces
B. Liquids
1. Properties of liquids
2. Equilibrium vapor pressure
C. Solids
1. Properties of solids
2. Crystalline structure
D. Changes of state

V. Solutions
A. Concentrations
1. Molar and formal
2. Normal
3. Molal
4. Percent
a. Volume
b. Mass
B. Chemical equilibrium
1. Mass-action expression
2. Equilibrium constant
C. Dissociation
1. Percent dissociation
2. Dissociation
D. Solubility
1. Solute-solvent relationships
2. Solubility constant
3. Precipitation
E. Electrochemistry
1. Electrolytes
2. Conductivity
3. Oxidation potentials

VI. Acid-Base Relationships
A. Acids, Bases, and Salts
B. Dissociation of Water
1. Basis of pH values
2. Kw value
3. Neutralization
4. Acid-Base titration
5. Hydrolysis
C. Butter solutions

VII. Element Properties and Relationships
- A. Hydrogen
- B. Oxygen
  - 1. Oxides
  - 2. Bonding in water crystals
  - 3. Freezing process of water
- C. Sodium and related chemicals
- D. Chlorine and related elements
- E. Calcium and related elements
- F. Nitrogen and related elements
- G. Transition elements

VIII. Organic Chemistry
- A. Carbon
  - 1. Bonding
  - 2. Hydrocarbons and derivatives
    - a. Saturated and unsaturated
    - b. Isomers
- B. Nomenclature
  - 1. Basic hydrocarbons
  - 2. Functional groups
    - a. Alcohols
    - b. Ketones
    - c. Acids
    - d. Esters
    - e. Ethers
    - f. Amines
  - 3. Aromatic hydrocarbons
- C. Organic reactions
  - 1. Decomposition properties
  - 2. Polymerization
  - 3. Chlorination

Texts and References:

Sienko and Plane, Chemistry (3rd Edition)

College Chemistry Laboratory Outline

I. Introduction
- A. Laboratory safety
- B. Equipment care and use

II. Use of Balances
- A. Triple Beam
- B. Top loading pan
- C. Chain-o-matic analytical
- D. Automatic analytical

III. Mass Volume Relationships
- A. Density of a solid
- B. Density of a liquid

IV. Formula from Experimental Data
- A. Weighing procedures
- B. Hood ventilation procedures
- C. Heating procedures
- D. Application of Gram-Atoms

V. Molar Solution
- A. Volumetric glassware
- B. Volumetric procedures
- C. Application of gram molecular weight

VI. Gas Analysis Based on Molar Volume
- A. Gas law application
- B. Properties of oxygen

VII. Normal Solutions
- A. Volumetric glassware and procedures
- B. Application of gram-equivalents

VIII. Analysis Based on Equivalent Weight
- A. Gas law application
- B. Properties of hydrogen
- C. Application of equivalent weight

IX. Ionic and Covalent Compounds
- A. Conductivity concept
- B. Ionic Reactions

X. Reversible Reactions and Chemical Equilibrium
- A. Shifting of equilibrium
- B. Precipitation in saturated solutions
- C. Filtration procedures

XI. The pH Determination of Solutions
- A. Indicators
- B. The pH meter
- C. Degree of ionization

XII. Acid-Base Titration
- A. Standard solutions
- B. Use of Volumetric equipment
  - 1. Buret
  - 2. Pipet
- C. Titration procedures
- D. Indicators
- E. Normality-volume relationships
- F. Neutralization application

XIII. Volumetric Analysis
- A. Titration procedures
- B. Application of equivalents as units in reactions

XIV. Equilibria
- A. Hydrolysis of salts
- B. Degree of hydrolysis

XV. Organic Properties
- A. Percent organic matter by ignition
- B. Flash point of organic liquid

Texts and References:

Frantz and Malm, Fundamental Experiments for College Chemistry, 2nd Edition

Course Title: Biology

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: None

Course Description and Objectives:

This survey course is designed to provide the student with a comprehensive knowledge of the fundamental concepts of modern biology. Although a molecular approach is considered, emphasis is placed on the structure and function of living organisms. The objective of this course is to prepare the student for more penetrating study in specialized areas of marine biology.

Major Divisions:

I. The Chemical Basis of Life
II. Physical Phenomena
III. Cytology
IV. Genetics and Evolution
V. Ecology
VI. Organism Characteristics and Classification

Outline of Instruction:

I. The Chemical Basis of Life
   A. Atomic Structure
   B. Bonds and Energy
   C. Molecules
   D. Organic Compounds

II. Physical Phenomena
   A. Molecular Movement
   B. Diffusion and Osmosis
   C. pH

III. Cytology
   A. Cell Components
   B. Mitosis
   C. Meiosis

IV. Genetics and Evolution
   A. Mendelian Genetics
   B. Modern Genetics
   C. Darwinism
   D. Mutation
   E. Gene Pools

V. Ecology
   A. Population, Community, and Ecosystem
   B. Community Interactions
   C. Symbiosis
   D. Marine Habitats

VI. Organism Characteristics and Classification
   A. Kingdom Monera
   B. Kingdom Protista
   C. Kingdom Metaphyta
   D. Kingdom Metazoa

General Biology Laboratory Outline

I. Use of the Microscope
   A. Parts of a Compound Microscope
   B. Methods of using a Microscope
   C. Calculating the Magnification
   D. Preparation of Temporary Mounts

II. Cell Morphology
   A. Onion Cells
   B. Muscle Cells
   C. Epidermal Cells

III. Mitosis and Meiosis
   A. Whitefish Blastula
   B. Gametes

IV. Genetics
   A. Monohybrid Cross
   B. Dihybrid Cross
   C. Probability
   D. Hardy-Weinberg Law

V. Monera
   A. Bacterial Cells
   B. Blue-Green Algae

VI. Protista
   A. Protozoa
   B. Algae

VII. Metazoa
   A. Starfish Dissection
   B. Crab Dissection

Texts and References:

Goodnight, Goodnight, and Armacost, Biology

Course Title: Elements of Oceanography

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: None, except admittance requirements

Course Description:

A first-year course in general oceanography. Many of the measurable parameters in the ocean environment are defined. Some problem areas in oceanography are mentioned. Potential uses of the sea are detailed as well as the geographical significance of the sea. Major morphological features of the sea bottom are described. A minor part of the course is devoted to elementary limnological considerations.

Major Areas of Discussion:

I. Introduction and History
II. Description of the Oceans
III. Geographical Significance of the Oceans
IV. Structure and Features of the Floors of Oceans
V. Water Masses
VI. Circulation and Currents
VII. Physical Properties of Sea Water
VIII. Marine Chemistry
IX. Temperature
X. Sea Ice
XI. Estuaries
XII. Introductory Concepts of Limnology
XIII. Classification of Lakes and Inland Waters
XIV. Physical and Chemical Properties of Fresh Waters

Outline of Instruction:

I. Introduction and History
   A. Early myths and legends
   B. The beginning of understanding 600 BC - 300 BC
   C. A lapse into darkness (300 BC - 1300 AD) and an age of enlightenment (14th century - 18th century)

II. Descriptions of the Oceans
   A. Size and extent in general terms
   B. Descriptions by early explorers
      1. Franklin
      2. Cook
      3. Maury
      4. Challenger Expedition
      5. Agassiz
      6. Prince Albert of Monaco

C. Decline in ocean exploration and discovery
   1. Shortage of funds
   2. Lack of first-rate oceanographers
   3. Magnitude of subject
D. New tools aid in new and renewed discoveries
   1. Math tables
   2. Sonar
   3. Seismology
   4. Scuba
   5. CCTV and cameras
E. Geologic time scale
F. Ocean expanses vs land areas
G. General bathymetric features of the oceans
   1. Shelf
   2. Slope
   3. Basin
   4. Trenches and deeps
   5. Terminology
H. Bottom configurations (ridges)

III. Geographical Significance of the Oceans
(inter-relationships between the oceans and the land)
A. Interaction of oceans and atmosphere
   1. Effects of atmosphere on oceans
      a. Wind
      b. Hydrologic cycle
   2. Effects of ocean on atmosphere and earth climate
B. The changing sea level
   1. Glaciation
   2. Temperature and salinity changes
C. Coastal change as influenced by marine forces
   1. Rise or fall in sea-level (disastrous forces)
   2. Wave action (normal shoreline forces)
D. Oceans in exploration and transportation
E. The strategic role of the oceans
F. The oceans as a source of food
G. International cooperation of world organizations in the study of the oceans

IV. Structure and Features of the Floors of the Oceans
A. The descent into the basins
B. The mid-oceanic ridge system
C. The Mohorovicic discontinuity and isostatic equilibrium
D. A digression - zones of the benthic region defined
E. Abyssal plains and abyssal hills
F. Deep-sea trenches (defined and name and location)

V. Water Masses
- A. Definition
- B. Sigma terminology
- C. T-S curve
- D. Classification of water masses
- E. Major water masses of each class

VI. Ocean Circulation and Currents
- A. Factors contributing to ocean circulation
- B. Classes of circulation
- C. Current systems
- D. Current features
  1. Gyral
  2. Westward displacement
- E. Major surface currents of the world's oceans
- F. Causes of the gyral systems
- G. Coriolis effect

VII. Physical Properties of Sea Water
- A. Temperature
- B. Pressure
- C. Salinity
- D. Chlorosity
- E. Density
- F. Thermal properties
  1. Effect of salinity on certain thermal properties
  2. Coefficient of thermal expansion
  3. Specific heat
  4. Coefficient of thermal conductivity
  5. Latent heat of fusion
  6. Latent heat of vaporization
- G. Colligative properties
- H. Miscellaneous properties
- I. Transmission of sound in sea water
- J. Transmission and effects of light in sea water

VIII. Marine Chemistry
- A. Law of relative proportions
- B. Factors influencing the composition of sea water
- C. Constituents of sea water
  1. Major and minor constituents
  2. Origin of dissolved constituents
- D. Gases in solution
- E. Pelagic deposits (calcareous and siliceous)

IX. Heat and Temperature
- A. Processes involved in heating of the oceans
- B. Processes involved in cooling of the oceans
- C. Heat budget and heat budget equation

D. Sea surface temperatures
E. The "three-layered ocean"
F. Temperature variations
G. Thermal microstructure

X. Sea Ice
A. Terminology and definitions
B. Movement (drift) of sea ice
C. Prediction and International Ice Patrol

XI. Estuaries
A. Definition
B. Estuary types classed by salinity distribution
C. Importance of estuarine environment
D. Need for continuing research and reclamation of our estuaries

XII. Introductory Concepts of Limnology
A. Limnology defined

XIII. Classification of Lakes and Inland Waters
A. Classification by succession type
1. Oligotrophic
2. Entrophic
3. Dystrophic
B. Classification according to how lake was formed

XIV. Physical and Chemical Properties of Fresh Water
A. Physical properties
1. Specific gravity (density)
2. Viscosity
3. Extinction of solar radiation
4. Distribution of heat
a. Sources of heat
b. Losses of heat
5. The "three-layered lake"
6. Currents in lake
B. Chemical properties
1. Dissolved salts
2. Oxygen
3. Carbon dioxide
4. Other important elements

Text and References:

Williams, Jerome, Oceanography: An Introduction to the Marine Sciences

Engel, Leonard, The Sea (Life Nature Series)

Hunt, Lee M., and Donald G. Groves, A Glossary of Ocean Science and Undersea Technology Terms

Course Title: American Literature

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: English Composition

Course Description and Objectives:

The purpose of this course is to introduce students to some of the major American writers of the twentieth century. The history of American literature is discussed. Literary forms studied include the novel, the short story, poetry and drama. Students are required to write a critical review based on individual study.

Major Divisions:

I. History of American Literature
II. Forerunners of the Twentieth Century: Crane and Twain
III. Lost Generation: Hemingway
IV. Art of Faulkner
V. Novel as Social Protest: Steinbeck and Wright
VI. Poetry: James Dickey
VII. Drama: Arthur Miller

Outline of Instruction:

I. History of American Literature
   A. Puritanism
   B. Romanticism
   C. Transcendentalism

II. Forerunners of the Twentieth Century: Crane and Twain
   A. Impressionism
   B. Realism
   C. Naturalism

III. Lost Generation: Hemingway
   A. Style
   B. Themes

IV. Art of Faulkner
   A. Style
   B. Themes

V. Novel as Social Protest: Steinbeck and Wright
   A. Social History of the Thirties
   B. Threat of Communism

VI. Poetry: James Dickey

VII. Drama: Arthur Miller

Texts and References:

Twain,	Huckleberry Finn
Crane,	Red Badge of Courage
Hemingway,	The Snows of Kilimanjaro and Other Stories
Faulkner,	Three Short Novels
Steinbeck,	In Dubious Battle
Wright,	Native Son
Lieberman,	The Achievement of James Dickey
Miller,	Death of a Salesman

Course Title: Physics I

Hours Required: Lecture, 3 hours; laboratory, 2 hours

Prerequisites: Algebra, 1 year; Trignometry, ½ year; Geometry, ½ year; General Science or some Physical Science, 1 year

Course Description and Objectives:

Modern approach to basic physics (non calculus) mechanics, with emphasis on quantitative relationships of rigid body motion, mechanical properties of matter and fluids. Laboratory will include physical measurements.

Major Divisions:

I. Review of Mathematics
II. Vector Analysis
III. Describing and Analyzing Motion
IV. Force and Motion
V. Friction
VI. Equilibrium
VII. Circular Motion
VIII. Energy
IX. Mechanical Advantage
X. Fluids
XI. Vibration Motion
XII. Waves

Outline of Instruction:

I. Review of Mathematics
   A. Algebra
   B. Equations
   C. Formulas
   D. Proportionality
   E. Graphs
   F. Exponents
   G. Exponential notation
   H. Measurements

II. Vector Analysis
   A. Vectors
   B. Vector Addition
   C. Trignometry
   D. Vector Subtraction
   E. Resolution of Vectors
   F. Component Method of Vector Addition

III. Describing and Analyzing Motion
- A. Speed - Constant, Instantaneous, Average
- B. Acceleration Motion
- C. Falling Bodies

IV. Force and Motion
- A. Laws of Motion - First, Second and Third Law of Motion
- B. Inertia and Mass
- C. Force and Motion
- D. Mass and Weight
- E. The British System of Units

V. Friction
- A. Sliding Friction
- B. Coefficient of Friction
- C. Static Friction
- D. Rolling Friction
- E. Fluid Friction

VI. Equilibrium
- A. Equilibrium of a Particle
- B. Torque
- C. Center of Gravity

VII. Circular Motion
- A. Uniform Circular Motion
- B. Centripetal Acceleration
- C. Centripetal Force
- D. Banked Turns
- E. Centrifugal Force
- F. Gravitation and the Gravitational

VIII. Energy
- A. Introduction
- B. Work
- C. Power and its Measurement
- D. Energy - Kinetic, Potential
- E. Conservation of Energy

IX. Mechanical Advantage
- A. The Lever
- B. The Wheel and Axle
- C. The Block and Tackle
- D. The Chain Hoist
- E. Belt Drive
- F. Gears
- G. The Inclined Plane
- H. The Wedge and Screw

X. Fluids
   A. Pressure
   B. Elasticity
   C. Young Modulus - Shear Modulus - Bulk Modulus

XI. Vibrational Motion
   A. Elastic Potential Energy
   B. Simple Harmonic Motion
   C. The Pendulum
   D. Position, Speed and Acceleration

XII. Waves
   A. Water Waves
   B. Longitudinal and Transverse Waves
   C. Wave Speed and Energy
   D. Standing Waves
   E. Resonance
   F. Sound
   G. Doppler Effect

Texts and References:

Beiser, Modern Technical Physics

Physics I Laboratory Outline

I. Measurement; the Meter Stick
II. Measurement; the Vernier Caliper
III. Measurement; the Micrometer Caliper
IV. Volume and Density
V. Specific Gravity of Solids
VI. Specific Gravity of Liquids
VII. Archimedes' Principle
VIII. Composition of Forces
IX. Resolution of a Force
X. Parallel Forces
XI. Machines; the Lever
XII. Coefficient of Friction
XIII. Machines; the Pulley
XIV. Machines; the Wheel & Axle
XV. Machines; the Inclined Plane
XVI. Power (Mechanical/Electrical)
XVII. Hooke's Law
XVIII. Newton's 2nd Law of Motion
XIX. Torsion Modulus
XX. Boyle's Law
XXI. The Ballistic Pendulum

XXII. Young's Modulus (wire)
XXIII. Acceleration Due to Gravity (Behr free-fall app.)

Texts and References:

SMVTI, Physics Laboratory Manual

Course Title: Computer Mathematics

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: Mathematics I

Course Description and Objectives:

The emphasis of this course is placed on learning how to use a numeric computer to solve problems in mathematics. Students are required to flow-chart and code problems in mathematics. The course is solution oriented with applications in statistics and a desk-top computer is used and available to all students.

Major Divisions:

I. The Whole Number System
II. The Rational Number System
III. The System of Integers
IV. Sample Spaces
V. Permutations
VI. Combinations
VII. Probability
VIII. Measures of Central Tendency
IX. Measures of Dispersion
X. Correlation

Outline of Instruction:

I. The Whole Number System
   A. Closure under the Operation of Addition
   B. Commutative Property of Addition
   C. Associative Property of Addition
   D. Whole Numbers under the Operation Multiplication
   E. Closure under the Operation of Multiplication
   F. Commutative Property of Multiplication
   G. Associative Property of Multiplication
   H. Distributive Property of Multiplication

II. The Rational Number System
   A. Equivalent Rational Numbers
   B. Renaming an improper fraction as a Mixed Number
   C. Fundamental Operations with Rational Numbers
   D. Solving any Proportion
   E. Repeating Decimals

III. The System of Integers
   A. Introduction to Integers
   B. Fundamental Operation with Integers

IV. Sample Spaces
- A. Finding Sample Spaces
- B. Computing Sample Spaces

V. Permutations
- A. Factorials
- B. Using a Computer to find N-Objects taken N at a time and K at a time

VI. Combinations
- A. Using a Computer to find the Combinations of N-Objects taken K at a time
- B. The Binomial Expansion

VII. Probability
- A. Outcomes Equally Likely
- B. Mutually Exclusive Events
- C. Not Mutually Exclusive Events

VIII. Measures of Central Tendency
- A. Computing the Arithmetic Mean
- B. Computing the Weighted Arithmetic Mean
- C. Computing the Arithmetic Mean from Grouped Data
- D. Computing the Median of Grouped Data
- E. Computing the Geometric Mean

IX. Measures of Dispersion
- A. Variance (Grouped and Ungrouped)
- B. Computing Standard Deviation
- C. Computing the Mean and Standard Deviation

X. Correlation
- A. Linear Correlation Coefficient between two sets of Data
- B. Mean, Standard Deviation and Correlation Coefficient

Texts and References:

McGillicuddy and et al, The Real Number System through Computers, Vol. I and II

Johnson and Berman, Probabilities and Statistics Through Computers

Course Title: Instrumentation and Methods in Oceanography

Hours Required: Class, 3 hours; laboratory, 2 hours
(every second week a full day of station work on vessel)

Course Description and Objectives:

A course in which the student will become familiar with all the more common oceanographic (and limnological) sampling tools and sampling methods. Field methods and field instruments (acquisition of samples and raw data) will be emphasized, but some time will be denoted to related ship's gear and laboratory equipment.

Major Areas of Discussion:

I. Water Sampling Gear and Methods
II. Plankton Samplers
III. Bottom Samplers
IV. Coring Devices
V. Current Measuring or Indicating Devices
VI. Temperature Measuring Devices
VII. Combined Purpose or Multipurpose Instruments

Outline of Instruction:

I. Water Sampling Gear and Methods
   A. Bucket
   B. Lumby surface sampler
   C. Insulated water bottle
   D. Nansen bottle - standard depths
   E. Knudsen bottle
   F. Kemmerer bottle
   G. Spilhaus-Miller sea sampler
   H. Fjarlie bottle
   I. Van Dorn bottle
   J. Frautschy bottle
   K. Niskin bottle
   L. N.I.O. water bottle
   M. Submersible pump
   N. Sterile water samplers
      1. Zobell bottle
      2. Cobet sampler
      3. Braincon multiple water sampler
   O. Large volume (barrel) sampler for C^{14} studies

II. Plankton Samplers and Methods
   A. Bucket
   B. Sample bottle itself

C. Submersible pump (qualitative and quantative methods)
D. Bacteria and nannoplankton samplers
   1. ZoBell bottle
   2. Cobet sampler
E. Birge-Juday plankton trap
F. Plankton net materials and mesh sizes
G. Simple cone net
H. Hensen net
I. Closing nets (non-mechanical)
J. Meter net (also 1/2, 1/4, 1/10 meter nets)
K. Hardy High Speed Plankton Indicator
L. Hardy Continuous Plankton Recorder
M. Isaacs-Kidd High Speed sampler
N. Clarke-Bumpus sampler
O. Gulf III and Gulf V samplers
P. Lamont Multiple Plankton Sampler

III. Bottom Samplers
A. Sounding lead
B. Petersen grab
C. Emery dredge
D. Van Veen dredge
E. Smith-MacIntyre sampler
F. Holme Scoop sampler
G. Dietz-LaFond sampler
H. Orange-peel sampler
I. Moore ooze sucker
J. Ekman dredge (Birge-Ekman dredge)
K. Exploratory scoop sampler
L. Underway bottom sampler (Scoopfish)
M. Bucket dredge
N. Pipe dredge
O. Oyster - scallop - rock dredge types
P. The selectivity of SCUBA
Q. Meter ^{2} frame

IV. Coring Devices
A. Brief history of coring
B. Hand corer
C. Moore sampler
D. Phleger corer
E. Piggot corer
F. Emery-Dietz gravity corer
G. Ewing piston corer
H. Kullenberg piston corer
I. Stetson free-falling corer
J. Russian barrel corer
K. The ball-breaker device (associated gear)
L. The "Boomerang" type of corer

V. Ocean Current Measuring or Indicating Devices
   A. Surface drifters
      1. Visual Indicators
         a. Paper
         b. Current log
         c. Dyes
      2. Release and find indicators
         a. Drift cards
         b. Drift envelopes
         c. Drift bottles
   B. Sub-surface drifters
      1. Release and find
         a. Bottom-trailer bottle
         b. Double bottles
         c. Sea-bed drifter
      2. Release and track
         a. Swallow float
   C. Current drogues and current drags
      1. Spar float
      2. Biplane float
      3. Biplane drag
   D. Current meters
      1. Ekman current meter
      2. Price pattern current meter
      3. Roberts radio current meter
      4. The geomagnetic electrokinetograph (GEK)
      5. Savonius rotor systems
   E. Use of a deep-sea camera to measure bottom currents

VI. Temperature Measuring Devices
   A. Stem thermometers
   B. The bathythermograph (BT) and Mosby thermo-sound
   C. The XBT system
   D. Reversing thermometers
   E. Max-min thermometer
   F. Thermistors
      1. In situ recorders
      2. NEL thermistor chain
   G. IR and remote sensors

VII. Combined Purpose and/or multipurpose instruments
   A. Navy Electronics Laboratory Deep Sea Oceanographic System (NELDSOS)
   B. SVTP STD
   C. ICTI
   D. Buoy platforms
   E. Geothermal probe

Texts and References:

Welch, P.S., Limnological Methods

Barnes, H., Oceanography and Marine Biology

Course Title: Invertebrate Zoology

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology

Course Description and Objectives:

The emphasis of this course is placed on the morphology, anatomy, and general biology of the major phyla of invertebrate animals.

Major Divisions:

I. Classification of Marine Environment
II. Factors Affecting Body Structure
III. Invertebrate Phyla
    1. Protozoa
    2. Porifera
    3. Coelenterata
    4. Ctenophora
    5. Platyhelminthes
    6. Rhynchocoela
    7. Aschelminthes
    8. Acanthocephala
    9. Entoprocta
    10. Annelida
    11. Mollusca
    12. Arthropoda
    13. Echinodermata
    14. Hemichordata
    15. Chordata

Outline of Instruction:

I. Classification of the Marine Environment
    A. Benthic
    B. Pelagic

II. Factors Affecting Body Structure
    A. Environment
    B. Size of animal
    C. Mode of existence

III. Invertebrate Phyla
    A. Protozoa
        1. Position in Animal Kingdom
        2. Characteristics of Phylum
        3. Characteristics of Classes
        4. Evolution
        5. Economic importance

B. Porifera
   1. Anatomy and Histology
   2. Basic sponge structures
   3. Physiology
   4. Characteristics of Classes
   5. Evolution
   6. Economic importance

C. Coelenterata
   1. New structural features
   2. Histology and Physiology
   3. Polyp and Medusoid structure
   4. Characteristics of Classes
   5. Evolution

D. Ctenophora
   1. New structural features
   2. Comparison with Coelenterata
   3. Characteristics of Classes
   4. Economic importance

E. Platyhelminthes
   1. Origin of bilateral symmetry
   2. Characteristics of Classes
   3. Evolution
   4. Economic importance

F. Ryhnchocoela
   1. Evolution
   2. Characteristics of Classes
   3. Economic importance

G. Aschelminthes
   1. Embryonic development of body cavity
   2. Evolution
   3. Histology, Physiology
   4. Economic importance

H. Acanthocephala
   1. Characteristics of Phylum
   2. Economic importance

I. Entoprocta
   1. Characteristics of Phylum
   2. Economic importance

J. Annelida
   1. Characteristics of Phylum
   2. Characteristics of Classes

3. Evolution
4. Economic importance

K. Mollusca
1. Characteristics of Phylum
2. Evolution
3. Characteristics of Classes
4. Economic importance

L. Arthropoda
1. Characteristics of Phylum
2. Reasons Phylum so successful
3. Classification of Classes, etc.
4. Evolution
5. Economic importance

M. Echinodermata
1. Characteristics of Phylum
2. Characteristics of Classes
3. Evolution
4. Economic importance

N. Hemichordata
1. Characteristics of Phylum
2. Characteristics of Classes
3. Evolution

O. Chordata
1. Characteristics of Phylum
2. Characteristics of Subphyla
3. Comparison of Invertebrates with Vertebrates

Texts and References:

Barnes, Invertebrate Zoology

Hickman, Integrated Principles of Zoology

Invertebrate Zoology Laboratory Outline

I. Field Trips
A. Collection methods of organisms from different environment
B. Preservatives and fixatives
C. Transportation of specimens

II. Exercise in Identification of Common Organisms
A. Phylum Protozoa
B. " Porifera
C. " Colenterata and Ctenophora
D. " Platyhelminthes and Rhychocoela
E. " Nematoda

F. " Rotifera, Gastrotricha & Nematomorpha
G. " Annelid
H. " Sipunculida, Echiurida and Chaetognatha
I. " Bryozoa and Brachiopoda
J. " Mollusca
K. " Arthropoda
L. " Echinodermata
M. " Prochordata

III. Anatomy and Structure
A. Transverse section of "Sycon" and "Halichondria"
B. Spicule mounts
C. Cross section of "Hydra"
D. Longitudinal section of "Anemone"
E. Regeneration experiment of "Planaria"
F. Parapodia mount
G. Dissection of "Neris"
H. Dissection of "Gastropoda"
I. Dissection of "Pelecypod"
J. Dissection of "Loligo"
K. Internal structure of "Balanus"
L. Dissection of a "lobster"
M. Dissection of a "Sea-cucumber"
N. Dissection of a "Sea Urchin"

Each student will be required to maintain a laboratory notebook, where he will keep a record of his laboratory work for evaluation.

Texts and References:

Smith, Ralph I., Editor, Keys to Marine Invertebrates of the Woods Hole Region

Course Title: Economics

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: Ability to comprehend College Level material in the field of Social Science

Course Description and Objectives:

The course attempts to give the student an understanding of our economic system; to demonstrate the role of money and its effect on the economy; to measure and understand production, employment, and income based on the circular flow concept; to explain business fluctuation, and to show the current methods of economic analysis and the development of economic policies that are used to stablize the levels of economic activity.

Major Divisions:

I. Economic System
II. Money, Credit and Banking
III. Production Income and Employment
IV. Business-Business Cycles Fluctuation
V. Income - Expenditure Analysis
VI. International Economics

Outline of Instruction:

I. Economic System
   A. Nature and Scope of Economics
   B. Process of Economizing
   C. Our Free Enterprise Economic System
   D. Circular Flow of Economic Activity

II. Money, Credit and Banking
   A. Money and Circular Flow
   B. Money - its Nature, Function and Creation
   C. Banking System
   D. Federal Reserve Control over Money Supply

III. Production, Income and Employment
   A. Production Income and the Flow of Funds
   B. Determinations of the GNP and Economic Growth
   C. Full Employment

IV. Business-Business Cycles Fluctuations
   A. Pattern of the Cycle
   B. Business Cycle
   C. Business Cycle, Monetary and Financial Causes

V. Income - Expenditure Analysis
   A. Anti-depressionary Policies
   B. Anti-inflationary Policies
   C. Evaluation of Income Expenditure Approach
   D. Fiscal Policy and the Department

VI. International Economics
   A. World Trade
   B. The Balance of International Payments
   C. International and Cooperation

Texts and References:

Hailstones, Basic Economics

Kiplinger, Changing Times

U.S. News and World Report

Time Magazine

Wall Street Journal

National Observer

Business Week

Course Title: Physics II

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: Physics 1

Course Description and Objectives:

The course is orientated to present a comprehensive treatment of basic technical physics (non-calculus). The approach is highly quantitative as stress is laid on problem solving and physical measurement in the experiments conducted. The objective of the course is to equip the student with some basic, logical understanding and skill in physical measurement, together with quantitative description and analysis.

Major Divisions:

I. Mechanical Properties
II. Heat
III. Electricity
IV. Magnetism

Outline of Instruction:

I. Mechanical Properties
   A. Density
   B. Elasticity
   C. Module of Elasticity
   D. Pressure
   E. Archimedes' Principal and Specific Gravity
   F. Bernoulli Equation
   G. Simple Harmonic Motion
   H. Water Waves
   I. Sound
   J. Doppler Effect

II. Heat
   A. Thermometry
   B. Thermal Energy
   C. Specific Heat
   D. Change of State
   E. Thermal Expansion
   F. Kinetic Theory of Gases
   G. First and Second Low of Thermodynamics
   H. Carnot Cycle
   I. Heat Transfer

III. Electricity (d.c.)
- A. Static Charge
- B. Electric Fields
- C. Ohm's Law
- D. Resistivity
- E. Kirchhoff's Rules
- F. Electrochemistry
- G. Fuel Cells
- H. Capacitance

IV. Magnetism
- A. Magnetic Properties
- B. Magnetic Fields
- C. Magnetic Forces
- D. Galvanometer, Ammeter and Voltmeter
- E. d.c. Motor
- F. The Betatron
- G. a.c. and d.c. Generators
- H. The Transformer
- I. Inductance
- J. a.c. Theory

Texts and References:

Beiser, Modern Technical Physics

Schaum, College Physics Outline

Physics II Laboratory Outline

I. Heat
- A. Calibrating a Thermometer
- B. Coefficient of Linear Expansion
- C. (Specific) Heat Capacity
- D. Charles' Law
- E. Heat of Fusion
- F. Heat of Vaporization
- G. Relative Humidity and Dew Point
- H. Heating Value of Fuel (Gas or Liquid)
- I. Electrical Equivalent of Heat

II. Sound
- A. The Simple Pendulum
- B. Vibration Rate of Tuning Forks
- C. Sonic Resonance

III. Light
- A. Photometry
- B. Reflection of Light

C. Index of Refraction
D. Lenses and Images
E. Spectroscopy

Texts and References:

SMVTI, Physics Laboratory Manual

Course Title: Survey of Navigation

Hours Required: Class, 3 hours; laboratory, 0 hours

Course Description and Objectives:

The emphasis of this course is placed on a study of the basics of navigation. A basic introduction to the earth and its coordinates, navigation tools, charts, navigation publications, visual and electronic aids to navigation is presented. The objective of the course is to enable the student to determine and plot marine positions. The course is solution oriented.

Major Divisions:

I. Dead Reckoning
II. Piloting
III. Aids to Navigation (Visual)
IV. Aids to Navigation (Electronic)

Outline of Instruction:

I. Dead Reckoning
   A. The Earth and its Coordinates
   B. The elements of Direction
   C. The Rhumb Line
   D. Great and Small Circles
   E. Distance, Speed
   F. Chart Projections, (Mercator)
   G. Latitude and Longitude
   H. Chart Interpretation
   I. Dead Reckoning Definitions
   J. The D. R. Track
   K. Time, Speed and Distance Solutions
   L. Navigation Instruments
   M. The Gyro Compass
   N. The Magnetic Compass

II. Piloting
   A. Construction of Plotting Sheets
   B. Lines of Position
   C. The Range
   D. The Fix
   E. Bearings, True and Relative
   F. The Running Fix
   G. Mathematical Solutions to the Fix
   H. Safe Piloting without a Fix
   I. Danger Bearings
   J. Danger Angles
   K. Tides
   L. Currents

III. Aids to Navigation (Visual)
- A. Buoys Significance and Systems
- B. Types of Buoys
- C. Daytime Buoy Identification
- D. Nighttime Buoy Identification
- E. Fog Signals
- F. Lighthouses
- G. Light Vessels
- H. Identification of Lights
- I. Range Lights
- J. Visibility of Lights
- K. List of Lights Publication

IV. Aids to Navigation (Electronic)
- A. Introduction to Electronic Aids
- B. Electronic Aids Publications
- C. Radio Direction Finders
- D. Marine Radio Beacons
- E. Radio Direction Finder Stations
- F. Errors in R.D.F. Bearings
- G. Radar Equipment
- H. Advantages and Limitations of Radar
- I. Radar Accuracy
- J. Radar Interpretation
- K. Radar Fixes
- L. Introduction to Maneuvering Board
- M. Loran Equipment
- N. Loran Charts
- O. Ground Waves and Sky Waves

Texts and References:

Dutton's, Navigation and Piloting

H.O. 2665-10, Maneuvering Board

Course Title: Field Biology (Ecology)

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology and Elements of Oceanography

Course Description and Objectives:

This course is designed for second year students who have had some familiarity with basic biological and oceanographic concepts. General definitions and principles of ecology will be explored with particular reference to the marine environment. Interrelationships between organisms and how the physical, chemical and geological features of the environment affect these relationships will be discussed in detail. Occasional field trips and student involvement in ecological projects will be encouraged.

Major Areas of Discussion:

I. Introduction and Early Ecological Thought
II. Basic Definitions in Ecology
III. Statistical Methods of Study and Research
IV. Physical Environmental Factors
V. Chemical Environmental Factors
VI. Geological Factors and Species Distribution
VII. Biogeochemical Cycles
VIII. Energetics and Productivity
IX. Population Dynamics
X. Inter and Intraspecific Competition
XI. The Community and Ecological Succession
XII. Classification and Ecology of the Marine Communities
XIII. Aquatic Pollution
XIV. An Ecological Approach to Harvesting the Sea

Outline of Instruction:

I. Introduction and Early Ecological Thought
  A. Additional literature and references
  B. History of Marine Ecology and Field Biology
    1. The new science
    2. The scientific method of ecological study
  C. The meaning of ecology
  D. Interdisciplinary ramifications
  E. The subdivisions of ecology
    1. autecology vs. synecology

II. Basic Definitions in Ecology
  A. The "Biological Spectrum"
    1. Organisms

2. Populations
3. Communities
4. Ecosystems
5. Biomes
6. Biosphere

B. Habitat
C. Niche

III. Statistical Methods of Study and Research
A. Sampling populations and the frequency distribution
B. Measures of central tendency
C. Chi square significance tests
D. Correlation coefficients
E. Graphic representations

IV. Physical Environmental Factors as "Limiting Factors"
A. Temperature
B. Salinity
C. Pressure
D. Illumination
E. Waves
F. Currents
G. Abrasion
H. Substratum
I. Tides

V. Chemical Environmental Factors as "Limiting Factors"
A. Oxygen
B. Carbon Dioxide
C. Hydrogen Sulfide
D. Hydrogen Ion Concentration
E. Inorganic Salts
F. Organic Compounds

VI. Geological Factors and Species Distribution
A. Continental Drift and species isolation
B. Submarine topography as barriers to distribution
C. Erosion and Abrasion
D. Marine sediments as a limiting factor
E. Diastrophic events

VII. Biogeochemical Cycles
A. General discussion
B. Nitrogen Cycle
C. Carbon Cycle
D. Phosphate Cycle
E. Quantitative Study of Biogeochemical Cycles
F. Other cycles

VIII. Energetics and Productivity
- A. Fundamental concepts related to energy
- B. Food chains and food webs
- C. Metabolism and size of individuals
- D. Trophic structure and ecological pyramids
- E. Concept of productivity

IX. Population Dynamics
- A. Population density and measurements
- B. Natality and Mortality
- C. Concepts of biotic potential and environmental resistance
- D. Cyclic oscillations of populations
- E. Population dispersal; internal distribution patterns
- F. Density-independent and density-dependent actions
- G. Population energy flow
- H. Aggragation and Allees Principle
- I. Isolation and Territoriality
- J. Plant Productivity Studies
  1. Carbon 14 fixation
  2. Oxygen consumption
  3. Dry weight studies

X. Inter and Intra Specific Competition
- A. Interspecies interactions
  1. Symbiotic relationships
- B. Competition
  1. Gause's Principle

XI. The Community and Ecological Succession
- A. The community concept
- B. Ecological dominance
- C. Classification of biotic communities
- D. Ecological succession
  1. Primary through climax communities
- E. Community Stratification
- F. Community Periodicity
- G. The Ecotone
- H. Species-numbers relationships
- I. Paleoecology

XII. Classification and Ecology of the Marine Communities
- A. General Introduction
- B. Habitats and Endemic Populations
  1. Abyssal
  2. Pelagic
  3. Upper Oceanic Zone
  4. Coastal
  5. Coral Reef
  6. Intertidal
  7. Estuarine

XIII. Aquatic Pollution
- A. Animal Wastes
- B. Industrial
- C. Chemical
- D. Thermal
- E. Atomic
- F. Herbicides and Pesticides
- G. Monitoring pollution and the Age of Computors
- H. Government controls; conservation and a new public awareness

XIV. An Ecological Approach to Harvesting the Oceans
- A. Aquaculture
  1. Fish farming
  2. Turtle farming
  3. Seaweed harvest
  4. Plankton culture
- B. Modern Conservation Techniques
  1. Whaling fisheries management
  2. Seal herds and other marine mammal protection
  3. Laws and Governments

Texts and References:

Odum, E.P.,	Fundamentals of Ecology
Hedgepeth,	Treatise on Marine Ecology and Paleoecology
Tait,	An Introduction to Marine Ecology
Moore, H.B.,	Marine Ecology
Benton and Werner,	Field Biology and Ecology
Hazen, W.E.,	Readings in Population and Community Ecology

Course Title: Chemical Oceanography

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: Elements of Oceanography and Instrumentation, and Methods in Oceanography

Course Description and Objectives:

A survey course of certain chemical and instrumental analytical methods specifically applicable to water and sea water analysis. Emphasis on procedure and technique of laboratory analyses rather than *in situ* measurements.

Methods Considered:

I. Salinity Determinations
II. Dissolved Oxygen Determinations
III. Acidity Determination
IV. Alkalinity Determination
V. pH Measurements
VI. Turbidity Measurements
VII. Suspended Solids Determinations
VIII. Phosphorus Determinations
IX. Nitrogen Determinations
X. Chlorophyll Determination
XI. Measurement of Primary Productivity
XII. Sediment Size Analysis

Outline of Instruction:

I. Salinity Determinations
   A. Basic chemistry of titrimetric methods
   B. Titrimetric methods (main emphasis)
      1. Knudsen method
      2. Mohr method
      3. Harvey method
   C. Gravimetric method
   D. Amperometric method
   E. Density (hydrometer) method
   F. Refractive index method
   G. Conductimetric methods (secondary emphasis)
      1. Conductivity cell
      2. (Beckman) RS-5C *in situ* salinometer
      3. Laboratory induction salinometer

II. Dissolved Oxygen Determination
   A. Winkler Method (main emphasis)
   B. Galvanic cell oxygen analyzer and *in situ* probes and monitors

III. Acidity Determination

IV. Alkalinity Determination

V. pH Measurements
- A. Definition of pH
- B. Colorimetric methods
  - 1. Color comparator
  - 2. Colorimeter
- C. pH Meter

VI. Turbidity Measurements
- A. Secchi disc
- B. Platinum wire method
- C. Candle turbidimeter
- D. Hellige turbidimeter
- E. Nephelometer
- F. Colorimeter
- G. Submersible photometer (transmissivity meter)
- H. Photocell

VII. Suspended Solids Determinations
- A. Evaporation method
- B. Filtration method
- C. Taring and ignition method (main emphasis)

VIII. Phosphorus Determinations
- A. Phosphorus fractions
- B. Inorganic phosphorus
- C. Total phosphorus

IX. Nitrogen Determinations
- A. The nitrogen fractions
- B. Determination of NH_3
- C. Determination of NO_3
- D. Determination of NO_2
- E. Determination of total nitrogen (Kjeldahl method) (main emphasis)

X. Chlorophyll Determination

XI. Measurement of Primary Productivity
- A. Dark and light bottle method
- B. Carbon-14 method

XII. Sediment Size Analysis
- A. Seiving
- B. Wentworth scale
- C Rapid sediment analyser

Texts and References:

Martin, D.F., Marine Chemistry, Vol. I

Standard Methods - A.P.H.A.

Course Title: Political Science

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: Ability to comprehend College Level material in the field of Social Science.

Course Description and Objectives:

This course is designed primarily for the student in college taking their first course in political science.

Major Divisions:

I. Framework of Government
II. Interest Groups and Pressure Tactics
III. Political Parties
IV. Voting and Elections
V. Nomination and Election of the President
VI. The Presidential Office
VII. Congress: The Membership
VIII. Congress at Work
IX. The Federal Courts
X. Civil Rights and Civil Liberties
XI. Man and the Land
XII. The Service State
XIII. Health, Education and Welfare
XIV. The Nation's Peace and Security

Outline of Instruction:

I. The Framework of Government
   A. The Farmers and Their Problems
   B. The Constitution: A Bundle of Compromises
   C. A Unique System of Government
   D. Dynamic Federalism
   E. Political Voting Behavior
   F. The Legal Setting for Voting Behavior

II. Interest Groups and Pressure Tactics
   A. Pressure Groups and Their Constituents
   B. Lobbies
   C. Pressure Groups, Yesterday and Today
   D. Public Opinion
   E. Group Membership
   F. Communication of the Groups Political Desires

III. Political Parties
   A. Comparison of Parties and Press re Groups

B. Parties: The Basis of Government
C. Party Membership
D. The Two Party System
E. Republican and Democratic Ratios
F. Decentralized Party Organization
G. Patterns of Party Preference
H. The American Voter, the Pattern of his Turnouts, and the Voter's Will at the Polls

IV. Voting and Election
A. Campaigning
B. Defensible Restrictions
C. The Mechanics of Voting
D. Proposed Reforms
E. Making Public Policy
F. The Struggle for Influence, Inside and Outside of the Government

V. The Nomination and Election of the President
A. Geographical determinants
B. National Convention
C. The Party Platform
D. The Campaign
E. The Electoral College
F. Political Leadership

VI. The Presidential Office
A. As a Legislation
B. Party Chieftain
C. Curbs on Presidential Power
D. Presidential Succession

VII. Congress: The Membership
A. Modes of Election
B. Qualifications
C. Background, Ethnic and Religious factors
D. Choosing Candidates

VIII. Congress at Work
A. Daily Routine
B. A Bill takes the Hurdles
C. Action in the House and Senate
D. Congressional Leadership

IX. The Federal Courts
A. Courts Jurisdiction
B. Structure of the Courts
C. Judicial Review
D. The Role of the Supreme Court

X. Civil Rights and Civil Liberties
   A. Restraints on the Government
   B. The Bill of Rights
   C. Constitutional Guarantees
   D. The Federal Role in Civil Rights

XI. Man and the Land
   A. Federal Subsidies
   B. Conservation
   C. Problems of Surplus
   D. The Effects of Mechanization

XII. The Service State
   A. Acts to Business
   B. Promotion and Regulation
   C. The Growth of Big Business
   D. The Balanced Wheel of the Economy

XIII. Health, Education and Welfare
   A. The Growth of Public Health Services
   B. Health and Social Security
   C. The Government and Education
   D. The Welfare State; Pro and Con

XIV. The Nations Peace and Security
   A. Security through Alliances
   B. The U.S. and Latin America
   C. The United Nations
   D. The Defense Establishment

Texts and References:

Fincher, Ernest B.,	The Government of the United States
Bone, Hugh A., and Austin Ranny	Politics and the Voter
Way, Frank H., Jr.,	Liberty in the Balance

Course Title: Sociology

Hours Required: Class, 3 hours; laboratory, 0 hours

Prerequisites: Graduation from High School

Purpose of the Course:

(I). To capture the interest of the student and to demonstrate the process and challenge of scientific observation and analysis of social behavior.

(II). To cultivate in the student the habit of scientific analysis of social behavior.

(III.) To present the basic concepts and descriptive materials of sociology clearly and intelligibly.

Major Divisions:

I. Sociology and Society
II. Culture and Personality
III. Social Organization
IV. Social Interaction
V. Human Ecology
VI. Social Change and Social Policy

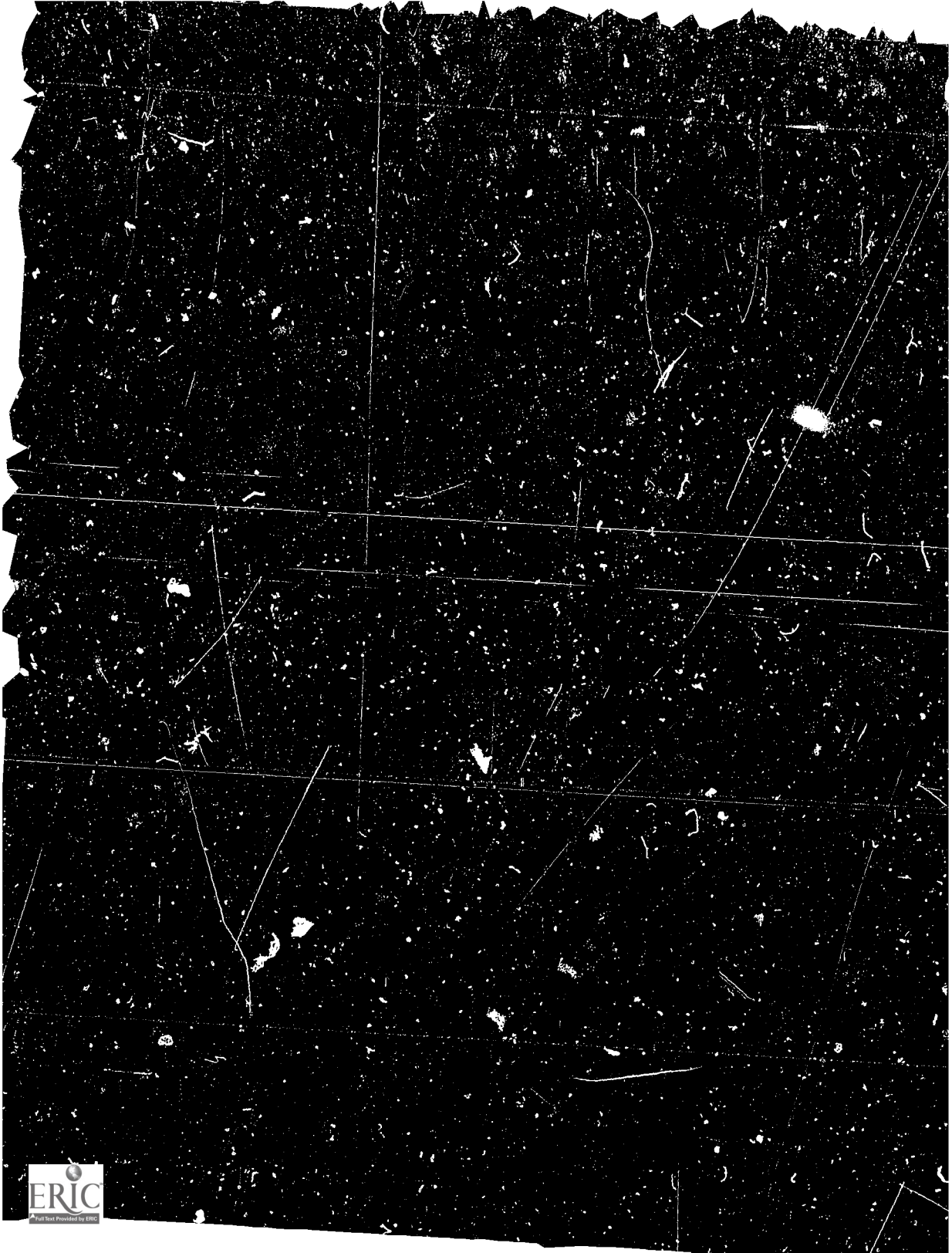
Outline of Instruction:

I. Sociology and Society
   A. Science and Society
   B. Fields and Methods of Sociology

II. Culture and Personality
   A. The Nature of Culture
   B. The Meaning of Culture
   C. Personality and Socialization
   D. Role and Status
   E. Social Control and Social Deviation

III. Social Organization
   A. Groups and Associations
   B. Social Institutions
   C. The Family
   D. Social Class
   E. Social Mobility

IV. Social Interaction
   A. Social Processes
   B. Social Power
   C. Race and Ethnic Relations
   D. Collected Behavior



V. Human Ecology
   A. Population
   B. Rural and Human Communities

VI. Social Change and Social Policy
   A. Social and Cultural Change
   B. Social Movements

Texts and References:

Horton and Hunt,	Sociology
Bailie, Helena,	Instructor's Manual for Horton and Hunt
Cohen, Bruce L., and Helena Bailie	Study Guide and Source Book
Huxley, Aldous,	Brave New World
Montague, Ashley,	Man In Process

Course Title: Microbiology

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology

Course Description and Objectives:

This course will study the basic principles and techniques of microbiology. Consideration will be given to microbial structure, growth, physiology, and the reactions of microorganisms to their physical, chemical and biological environments. Whenever possible, emphasis will be placed on marine microorganisms.

Major Areas of Discussion:

I. Introduction
II. History
III. Biological Principles
IV. Bacterial Anatomy
V. Microbial Nutrition and Physiology
VI. Techniques of Growing Bacteria
VII. Bacterial Growth
VIII. Influence of Environment
IX. Groups of Bacteria
X. Control of Microorganisms
    1. Physical Agents
    2. Chemical Agents
    3. Antibiotics
XI. Resistance to Harmful Agents
XII. Microbiology of Water and Sewerage
XIII. Pathogens and Virulence
XIV. Host Defense Mechanisms
XV. Immunity and Vaccines
XVI. Water-borne Infections of Man
XVII. Contact Diseases of Man

Outline of Instruction:

I. Introduction
    A. General scope of microbiology
II. History
    A. Beginning of microbiology
    B. Pertinent discoveries
III. Biological Principles
    A. DNA replication and transcription
    B. Metabolism
    C. Microbial nomenclature and classification

D. Microscopy
   1. Bright-field microscopy
   2. The function of oil
   3. Phase-contrast microscopy
   4. Electron microscopy

IV. Bacterial Anatomy
   A. Shape and arrangement of bacterial cells
   B. Bacterial size
   C. Bacterial structures
      1. Flagella
      2. Fimbriae
      3. Capsules
      4. Cell wall
      5. Cytoplasmic membrane
      6. Protoplasm
      7. Endospores

V. Microbial Nutrition and Physiology
   A. Nutritional requirements
   B. Physical conditions required for growth
      1. Temperature
      2. Gaseous requirements
      3. pH
      4. Salinity

VI. Techniques of Growing Bacteria
   A. Bacteriological media
      1. Types of media
      2. Procedure for making media

VII. Bacterial Growth
   A. Growth curve of a bacterial population
      1. Lag phase
      2. Log phase
         a. Generation time
      3. Stationary phase
      4. Death phase
      5. Survival phase

VIII. Influence of Environment
   A. Factors influencing phases of growth curve

IX. Groups of Bacteria
   A. Orders of bacteria
      1. Pseudomonadales
      2. Chlamydobacteriales
      3. Hypomicrobiales
      4. Eubacteriales
      5. Caryophanales
      6. Actinomycetales
      7. Beggiatoales

8. Myxobacterales
9. Spirochaetales
10. Mycoplasmatales

B. The Viruses

X. Control of Microorganisms
A. Terminology
1. Sterilization
2. Disinfectant
3. Antiseptic
4. Bactericide
5. Antimicrobial agent
6. Etc.
B. The Pattern of Death of Bacteria
C. Conditions Influencing Antimicrobial Action
D. Physical Agents
1. Temperature
2. Desiccation
3. Radiation
4. Ultraviolet light
5. Surface tension
6. Bacteriological filters
E. Chemical Agents
1. Desirable features of chemical agents
2. Major groups of chemical antimicrobial agents
F. Antibiotics
1. The sulfonamides
2. How antibiotics work
3. Types of antibiotics

XI. Resistance to Harmful Agents
A. Resistance to antibiotics

XII. Microbiology of Water and Sewerage
A. Marine microbiology
1. Role of Marine microorganisms
2. Fertility of oceans
3. Water purification
4. Coliform test
5. Characteristics of sewerage
6. Sewerage treatment and disposal

XIII. Pathogens and Virulence
A. Factors influencing virulence
B. Enzamatic factors
C. Factors influencing infection
D. Infective dosage
E. Portal of entry
F. Communicability

XIV. Host Defense Mechanisms
- A. The first line of defense
- B. The second line of defense
- C. The third line of defense

XV. Immunity and Vaccines
- A. Active immunity
- B. Passive immunity
- C. Antigens
- D. Vaccines

XVI. Water-borne Infections of Man
- A. Control of intestinal infections
- B. The carrier problem
- C. Various infectious bacteria

XVII. Contact Diseases of Man
- A. Direct-contact diseases
  1. Syphilis
  2. Gonorrhea
  3. Streptococcus infections
  4. Staphylococcus infections
  5. Tetnus
  6. Rabies
  7. Etc.

Texts and References:

Pelczar, Michael, J., and Roger D. Reid — Microbiology

Stanier, — The Microbial World

Microbiology Laboratory Outline

I. General Laboratory Techniques
- A. Aseptic transfer of bacteria
- B. Streaking a plate for isolation of colonies
- C. Identification of bacterial structural types
  1. Cocci
  2. Bacilli
  3. Spirilla

II. Preparation of Media
- A. Preparation of sea water extract
- B. Incubation of sea water colonies
- C. Isolation of pure colonies

III. Dilution Counts by the Pour Plate Method

IV. Test for the Presence of Bacteriophage in Sea Water
- A. Method to isolate phage
- B. Method to detect phage
- C. Methods used for direct counting of bacteria

V. Thermal Death
- A. Determine half life of spores of Bacillus megaterium

VI. Enrichment Cultures
- A. Blue-green algae
- B. Green algae
- C. Nitrogen-fixing bacteria
- D. Cellulose decomposing bacteria
- E. Aerobic sporeformers
- F. Anaerobic sporeformers

VII. Determination of Bacterial Characteristics
- A. Spore stain
- B. Capsule outline
- C. Gram stain
- D. Flagella stain
- E. Nuclear stain
- F. Simple stain
- G. Lipid stain
- H. Periodate - Schiff stain
- I. Acid-Fast stain

VIII. Photoelectric Colorimetry and Turbidimetry
- A. Determination of spore generation with a Spec.-20

IX. Coliform Test
- A. Millipore filter apparatus
- B. Fermentation tube technique

Course Title: Physical and Geological Oceanography

Hours Required: Lecture, 3 hours; laboratory, 2 hours

Prerequisites: Elements of Oceanography

Course Description and Objectives:

A second year course in Physical and Geological Oceanography. This course will expand upon the concepts taught in Oceanography I, as well as introducting new topics. Emphasis will be put upon some of the modern research being carried out in the various fields being discussed.

Major Divisions:

I. The Earth; its Origin, Structure, and Composition
II. Techniques for Exploration of the Sea Floor
III. Topography of the Sea Floor
IV. Pelagic Sediments
V. Abyssal Plain Sediments
VI. Movements of the Sea Floor
VII. Igenous Rocks of the Ocean Floor
VIII. The Structure of the Ocean Basins
IX. Continental Drift
X. Beaches
XI. Physical Properties of Sea Water
XII. Typical Distributions of Water Characteristics
XIII. Water, Salt, and Heat Budgets of the Oceans
XIV. Circulation and Water Masses of the Oceans
XV. Coastal Oceanography
XVI. Waves and Currents
XVII. Current Topics in Applied Oceanography

Outline of Instruction:

I. The Earth; its Origin, Structure, and Composition
    A. Formation of the Earth
    B. Geological time table
    C. The layers of the Earth
        1. The Atmosphere
        2. The Hydrosphere
        3. The Lithosphere
            a. The Crust
            b. The Mantle
            c. The Core
    D. The type of rocks and rock-forming minerals

II. Techniques for Exploration of the Sea Floor
- A. Seismology
- B. Echo-sounding and Seismic profiling
- C. Earthquakes
- D. The Earth's magnetic field
- E. Heat-flow measurement
- F. Project Mohole
- G. Submersible vehicles
- H. Underwater television
- I. Remote photographic equipment

III. Topography of the Sea Floor
- A. The Continental Shelf
- B. The Continental Slope
- C. The Continental Rise
- D. The Ocean Basin
- E. Submarine Canyons
- F. Reefs
- G. Ridges
- H. Trenches
- I. Atolls
- J. The Mid-Ocean Ridge System
- K. Bathymetric Charts

IV. Pelagic Sediments
- A. Types
- B. Age determination of sediments
- C. Magnetic Stratigraphy
- D. Mineralogy of sediments
- E. Devices for sampling sediments
- F. Applications of studies of Pelagic sediments
  1. Indicator species
  2. Polar migration

V. Abyssal Plain Sediments
- A. Iberian
- B. Biscay Plains

VI. Movements of the Sea Floor
- A. Evidence of vertical movement
- B. Evidence of lateral movement

VII. Igneous Rocks of the Ocean Basins
- A. Basic and Ultra-Basic rocks
- B. Oceanic Islands
- C. Mid-Ocean Ridge
- D. Basalts
- E. Manganese

VIII. The Structure of the Ocean Basins
- A. Mid-Ocean Ridge system
- B. The Continental margins

IX. Continental Drift
- A. Ocean floor spreading
- B. Polar wandering

X. Beaches
- A. Terminology
- B. Types
- C. Characteristics
- D. Cycles

XI. Physical Properties of Sea Water
- A. Salinity
- B. Conductivity
- C. Sound
- D. Temperature
- E. Density
- F. Pressure
- G. Color
- H. Chlorinity
- I. Chlorosity
- J. Refractive Index

XII. Typical Distribution of Water Characteristics
- A. Density distributions
- B. Dissolved oxygen distributions
- C. Temperature distribution
- D. Salinity distribution

XIII. Water, Salts, and Heat Budgets of the Oceans
- A. Conservation of Volume
- B. Conservation of Salt
- C. Conservation of Heat Energy

XIV. Circulation and Water Masses of the Ocean
- A. General description
- B. Southern Ocean
- C. Atlantic Ocean
- D. Mediterranean, Black, and Baltic Seas
- E. Northern Seas
- F. Artic Seas
- G. Pacific Ocean
- H. Indian Ocean
- I. Red Sea

XV. Coastal Oceanography
- A. Estuaries
- B. Bays
- C. Flushing Time

XVI. Waves and Currents
- A. Causes
- B. Terminology and Ideal waves
- C. Progressive Oscillatory waves
- D. Wind waves
- E. The Beaufort Scale
- F. Young and Old waves
- G. Dwell
- H. Shallow water waves
- I. Wave refraction
- J. Breakers
- K. Currents set in motion by shoaling waves
- L. Tsunamis
- M. Storm Surges
- N. Tides and tidal currents
- O. Turbidity Currents
- P. Internal Waves

XVII. Current Topics in Applied Oceanography

Texts and References:

Keen, M. J.,	An Introduction to Marine Geology
Pickard, G.L.,	Descriptive Oceanography
Shepard, Francis, P.,	The Earth Beneath the Sea
Yasso, Warren, P.,	Oceanography
Spar, J.,	Earth, Sea, and Air
Sverdrup, Johnson, and Flemming,	The Oceans

Physical and Geological Oceanography Laboratory Outline

I. Fossil Study
   A. A study of the methods by which fossils form
   B. Observation and identification of various fossils

II. Rock and Mineral Study
   A. The observation and identification of rocks and minerals
      1. Igneous
      2. Metamorphic
      3. Sedimentary

III. Core Analysis
   A. Analysis of CLAY cores for determination of particle type and size

IV. Core Analysis
   A. Analysis of MUD cores for determination of particle type and size

V. Foraminifera and Diatoms
   A. A study of sediment samples for the tests of diatoms and foraminifera
   B. Students will observe under a microscope and will sketch those specimens they find

VI. Clastic Study
   A. Investigation of local clastics to determine size, shape, mineral make-up, abundance and location

VII. Field Trips
   A. To observe movements of particles, structures associated with each phenomenon, its formation and erosion
      1. Lagoon
      2. Beach
      3. Bar
      4. Rocky coast

Course Title: Planktology (Elective)

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology and Invertebrate Zoology

Course Description and Objectives:

The emphasis of this course is placed on the structure and dynamics of marine plankton communities, classification, morphology, and ecology of major constituents. Laboratory will be involved in collecting, sorting, and identification of local biota.

Major Divisions:

I. Introduction
II. Familarity with Different Terminology
III. Phytoplankton
IV. Zooplankton
V. Planktonic Larvae
VI. Ichthyoplankton
VII. Factors Affecting Primary Production
VIII. Plankton and the Fisheries

Outline of Instruction:

I. Introduction
   A. Historical aspects
   B. Quantitative approach

II. Familarity with Different Terminology
   A. Relation to size
      1. Megaplankton
      2. Macroplankton
      3. Nanoplankton
      4. Ultraplankton
      5. Microflagellates
      6. Hekistoplankton
   B. Relation to the number of species
      1. Monomictic
      2. Polymictic
      3. Pantomictic
   C. Relation to nutrition
      1. Autotrophic
      2. Auxotrophic
      3. Heterotrophic
      4. Saprozoic
      5. Myxotrophic
      6. Holotrophic

III. Phytoplankton
- A. Diatoms
  - 1. Centricae
  - 2. Pennatae
- B. Dinoflagellata

IV. Zooplankton
- A. Phylum Protozoa
- B. " Coelenterata
- C. " Ctenophora
- D. " Chaetognatha
- E. " Annelida
- F. " Phoronida
- G. " Mollusca
- H. " Urochordata

V. Planktonic Larvae
- A. Polychaete larvae
- B. Crustacean larvae
- C. Gastropod larvae
- D. Lamellibranch larvae
- E. Ectoproct larvae
- F. Echinoderm larvae

VI. Ichthyoplankton
- A. Fish eggs
- B. Fish larvae

VII. Factors Affecting Primary Production
- A. Nutrients
- B. Light and temperature
- C. Organic micro nutrients and inhibitors
- D. Grazing

VIII. Plankton and the Fisheries
- A. Food
- B. Distribution and migration
- C. Fishing
- D. Mortality

Texts and References:

Raymond, Plankton and Productivity

Hardy, The Open Sea, Part I

Newell and Newell, Marine Plankton

Planktology Laboratory Outline

I. Collection of Plankton
   A. Meter net
   B. High speed sampler
   C. Clark-Bumpus sampler
   D. Gulf III, plankton sampler

II. Techniques for Studying Plankton Abundance
   A. Numerical method
      1. "Y" splitter
      2. Sorting tray
      3. Folsom splitter
      4. Cushing splitter
   B. Volumetric method
   C. Gravimetric method

III. Identification of Major Groups

IV. Preservation and Preparation of Slides

Course Title: Microtechnique (Elective)

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology

Course Description and Objectives:

An introduction to the procedures involved in the preparation of materials for microscopic examination, including instruction in fixation, embedding, sectioning, and staining. The course is oriented towards laboratory technique in the subject.

Major Areas of Discussion:

I. Introduction
II. Types of Microscope Slides
III. Materials and Equipment
IV. Fixation and Fixatives
V. Stains and Staining
VI. Dehydrating and Clearing
VII. Sectioning
VIII. Cleaning, Labeling, and Storing Slides

Outline of Instruction:

I. Introduction
   A. Outline the general nature of the course

II. Types of Microscope Slides
   A. Wholemounts
   B. Smears
   C. Squashes
   D. Sections

III. Materials and Equipment
   A. Slides and Coverslips
   B. Containers for Handling Objects
   C. Equipment for Handling Slides

IV. Fixative Mixtures
   A. Purpose of Fixation
   B. Preservation of External Form
   C. Preservation of Cellular Detail
   D. Fixative Mixtures

V. Stains and Staining
   A. Principles of Staining
   B. Nuclear Stains

C. Plasma or Contrast Stains
D. Staining Procedures

VI. Dehydrating and Clearing
A. General Principles
B. Clearing Agents

VII. Sectioning
A. Nature of the Process
B. Methods of Holding Materials
C. Hardening and Fixing Materials for Cutting
D. Choice of Fixatives
E. Technique of Dehydrating, Clearing, Embedding

VIII. Cleaning, Labeling, and Storing Slides
A. Cleaning
B. Labeling
C. Storing

Texts and References:

Gray, Handbook of Basic Microtechniques

Mahoney, Laboratory Techniques in Zoology

Course Title: Marine Botany (Elective)

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology

Course Description and Objectives:

This course is designed to introduce the student to the major groups of marine algae as well as to the vascular plants which exist in shore areas. Emphasis is placed on morphology, zonation, physiology, and evolution.

Major Areas of Discussion:

I. Vascular Plant Taxonomy
II. Salt Marshes
III. Sand Dunes
IV. Bacteria in the Sea
V. Marine Fungi
VI. Planktonic Organisms
VII. Cyanophyta
VIII. Basic Botany of the Algae
IX. Chlorophyta
X. Phaeophyta
XI. Macrocystis - A Case Study
XII. Rhodophyta
XIII. Zonation of a Rocky Shore
XIV. Physiology of the Algae
XV. Phylogeny and Fossil Algae
XVI. Commercial Marine Plants of Maine

Outline of Instruction:

I. Vascular Plant Taxonomy
   A. Terminology
   B. Trends in floral evolution
   C. Dicotyledonae
   D. Monocotytedonae

II. Salt Marshes
   A. Introduction - value of a salt marsh
   B. Geology
   C. Zonation of marsh plants
   D. Adaptations of halophytes

III. Sand Dunes
   A. Types of shores
   B. Formation of dunes

C. Succession of plant and animal communities
D. Factors affecting zonation on sand dune and beach areas
E. Adaptations of selected plants

IV. Bacteria in the Sea
A. Types of bacteria found in marine environment
B. Microorganisms of estuarine and nearshore waters
C. Source of microorganisms in nearshore waters
D. Mineralization of organic wastes
E. Microbial interactions in water

V. Marine Fungi
A. Introduction
1. Definition
2. Evolution
B. Slime molds
C. True fungi

VI. Planktonic Organisms
A. Populations of marine organisms
B. Classification by size
C. Phytoplankton
1. Diatoms
2. Dinoflagellates
3. Other phytoplankton
D. Methods of suspension
E. Factors affecting distribution of phytoplankton
F. Seasonal variations
G. Applications to research

VII. Cyanophyta
A. General features
B. Families
C. Probable evolution
D. Ecology

VIII. Basic Botany of the Algae
A. Introduction
B. Adaptations to benthic environment
C. Structure of the stipe
D. The blade
E. Reproduction in algae
F. World wide distribution of major groups of algae

IX. Chlorophyta
A. Cell structure
B. Asexual reproduction
C. Sexual reproduction
D. Distribution

E. Pigments
F. Marine orders
G. Proposed phylogenetic arrangement

X. Phaeophyta
A. General characteristics
B. Methods of classification - types of life cycles
C. General growth patterns
D. Representative marine orders
E. Suggested phylogenetic arrangement

XI. Macrocystis - A Case Study
A. Organic productivity of giant kelp areas
B. Study of kelp-grazing organisms
C. Microbiological aspects of the kelp bed environment

XII. Rhodophyta
A. General characteristics
1. Patterns of growth
2. Distribution
B. Pigments
C. Food storage products
D. Reproduction
E. Representative orders
F. Suggested phylogenetic arrangement

XIII. Zonation of a Rocky Shore
A. Zones of tidal exposure
B. Factors affecting zonation

XIV. Physiology of the Algae
A. Nutritional requirements
B. Osmo-regulation
1. Chief halides involved
2. Mechanisms

XV. Phylogeny and Fossil Algae
A. Phylogeny
1. General statements
2. Suggested phylogenetic lines of development
B. Fossil and Physiological evidence for phylogeny

XVI. Commercial Marine Plants of Maine
A. Irish moss
1. History
2. Uses for carrageenin
3. Structure
4. Management of industry

B. Equipment and methods used in gathering and processing Irish moss
C. Small businesses in seaweeds
D. Eelgrass
   1. History
   2. Biological importance
   3. Commercial importance

Laboratory Outline:

I. Treatment of experimental data
II. Plant reproduction
III. Bacteria - morphology and gram stain
IV. Diatoms
V. Survey of algal forms
VI. Carrageenin - extraction methods and uses
VII. Collecting procedures
VIII. Collecting trip
IX. Field trip to Kraft Foods (Carrageenin processing plant)
X. Identification of algal collections

Texts and References:

Dawson, Yale E., Marine Botany

Taylor, W. T., Marine Algae of the Northeastern Coast of North America

Course Title: Fishery Science (Elective)

Hours Required: Class, 3 hours; laboratory, 2 hours

Prerequisites: General Biology and Invertebrate Zoology

Course Description and Objectives:

This course will include studies of the biology of the commercially important fishes, methods of fisheries research, fishing methods, and fishing techniques of the world. Laboratory will be devoted to methods of age and growth determination, identification, fish tagging along with several field trips to local fisheries industries.

Major Areas of Discussion:

I. Introduction
II. Classification
III. Functional Morphology and Anatomy of Fishes
IV. Age and Growth
V. Races of Subpopulation
VI. Vital Statistics of the Population
VII. Tagging of Fish
VIII. Aquaculture
IX. Fishing Gear
X. Fisheries Technology
XI. Crustacean Fishery
XII. Molluscan Fishery
XIII. Managing Natural Population
XIV. Life History of some Economic Species

Outline of Instruction:

I. Instruction
   A. The general nature, limits, and status of the field

II. Classification
   A. Origin and phylogeny of the major groups of fishes.

III. Functional Morphology and Anatomy
   A. External anatomy
      1. Body regions
      2. Body shape
      3. Fins
      4. Body covering
   B. Internal anatomy
      1. Skeleton
      2. Muscular systems
      3. Respiratory-circulatory systems

4. Digestive systems
5. Excretory systems
6. Reproductive systems
7. Nervous systems

IV. Age and Growth
A. Methods of determining growth
B. Methods of determining age

V. Races of Subpopulation
A. Races and their geographic extent
B. Selection of racial characters
C. Methods of racial selection

VI. Vital Statistics of the Population
A. Methods of estimating population size
B. Factors affecting population size
C. Collection of basic data

VII. Tagging of Fish
A. Types of tags and information sought
B. Techniques of tagging and recovery

VIII. Aquaculture
A. Pond culture
B. Lacustrine fisheries
C. Estuarine fisheries
D. Brackish water fisheries

IX. Fishing Gear
A. Types of fishing gear and their uses

X. Fisheries Technology
A. Sources of the products
B. Marketing of the products
1. Processing
2. Fresh fillet
3. Canned fish
4. Curring
5. Salting
6. Smoking

XI. Crustacean Fishery
A. Crabs
B. Lobster
C. Shrimp

XII. Molluscan Fishery
- A. Mussels
- B. Oyster
- C. Clams

XIII. Managing Natural Populations
- A. Management techniques
- B. Fishways
- C. Pollution
- D. Overfishing
- E. Regulation and its effects

XIV. Life History of some Economic Species
- A. Flatfish
- B. Herring
- C. Cod family
- D. Tuna
- E. Salmon
- F. Whiting
- G. Haddock

Texts and References:

Rounsefell and Everhart,	Fishery Science
Lagler,	Fresh Water Fishery Biology
Lagler, Bardach and Miller,	Ichthyology
Bigelow and Schroeder,	Fishes of the Gulf of Maine

Fishery Science Laboratory Outline:

I. Dissection of Shark and Perch
- A. General external morphology
- B. Internal anatomy

II. Keys to the common fishes

III. Technique for Life History Studies
- A. Measurement, length, and weight
- B. Scale processing and mounting
- C. Scale reading
- D. Examination of other parts, i.e., Otolith, Vertebrae, Operculum and Dorsal Spine
- E. Technique in fish tagging
- F. Stomach analysis

IV. Demonstration in Fishing Gear Technique
- A. Ocean trip
- B. Technique in making knots and mending nets
- C. Model fish traps

V. Field Trips
- A. Fish farms
- B. Aquariums
- C. Hatcheries
- D. Fish Processing Plants

Sample Laboratory Experiment (Chemistry)

TITLE: ACID-BASE TITRATION

Purpose:

To standardize an alkaline solution by Titration, using a carefully prepared acid as a standard.

Special Equipment:

One 50 ml buret and buret clamp
One 25 ml pipet
One 250 ml volumetric flask

Chemicals:

Oxalic acid crystals ($H_2 C_3 O_4 .2H_2O$)
Sodium Hydroxide Solution (approx. 6N)
Phenolphthalein indicator

Procedure:

1. Preparation of standard Oxalic Acid. - Carefully weigh a 100 ml beaker to a constant weight of $\pm$ 0.001 g. Place 7-9 g of pure oxalic acid crystals, $H_2 C_3 O_4 .2H_2O$, in the beaker and again weigh to a constant weight of $\pm$ 0.001 g. Calculate the exact weight of the oxalic acid in the beaker.

   With the aid of a stirring rod, carefully transfer the weighed crystals, without loss, to a clean 250 ml volumetric flask. Rinse the last powder from the beaker into the flask with distilled water, and then add distilled water until the flask is slightly more than half full. Gently mix the solution by swirling it in the flask. When all the acid is dissolved, fill the flask carefully to the mark. Cap the flask and mix the solution well by repeated inversion and swirling.

   From the exact weight of the acid, formula weight (including the water of crystallization), gram-equivalents, and final volume, calculate the normality of your standard acid solution.

2. Preparation of the Sodium Hydroxide Solution to be standardized - Dilute 40 ml of the approximately 6N solution of NaOH with 440 ml of water. Mix the solution thoroughly in a stopped flask by repeatedly inverting and swirling the solution. Calculate the approximate normality of your NaOH by using a dilution ratio.

3. Titration - Clean thoroughly a buret and a 25 ml pipet, using a small amount of soap solution and a buret brush if necessary. Rinse these thoroughly, first with tap water, then with distilled water and drain.

Rinse the buret with a small amount of your NaOH solution; reject the rinsing. Repeat the rinsing a second time and reject the rinsing.

Fill the buret with your NaOH solution, making sure there are no air bubbles in the tip of the buret. Adjust the level of the NaOH in the buret to the zero mark, catching the discharge solution in a beaker. Touch off the drop adhering to the tip on the side of the beaker.

Rinse the pipet twice with a small amount of your oxalic acid. Using the pipet, transfer exactly 25 ml of oxalic acid to a clean 250 ml erlenmeyer flask.

Add (2) drops of phenolphthalein, then titrate by adding NaOH from the buret. Mix the solution in the flask by swirling while titrating. As the end point is approached, which is indicated by the fact that the pink color disappears less rapidly, add the NaOH slowly, drop by drop, until the final drop leaves a slight pink color which persists. Make two additional titrations of your solution. Calculate the exact normality of your NaOH solution.

Sample Laboratory Experiment (Physics)

TITLE: PHOTOMETRY

Purpose:

To measure the intensity of various light sources, using the optical bench.

Equipment:

Optical bench, single-bar form; photovoltaic cell; 50-uA meter; 8-candela standard source; "unknown " light sources; accessories.

Introduction:

The illuminance (level of illumination) from a point source of light without reflector follows the inverse-square radiation law; that is, the illuminance E varies inversely with the square of the distance r from the source.

Equation .1: $$E \text{ (illuminance)} = \frac{I}{r^2}$$

where I is the intensity of the source in candelas (cd), and r is the distance from the source to the surface illuminated, in meters, for illuminance in lumens per square meter.

The older name for the intensity unit was candlepower, but this was changed to candela in name, only, to make it more international. The unit itself has not changed except to be redefined in terms of the luminous flux from 1/60 of a cm^2 of the surface of melting platinum, at 1755° C.

An older unit of illuminance in this country has been the foot-candle; the illumination on a surface one foot from a one-candle power (candela) source. A new unit of luminous flux is the lumen. The lumen is the level of light energy striking a square meter of surface at a distance if one meter from a 1-candela source. Since there are 4 π (12.57) square meters of surface area on a sphere of 1-meter radius, a one-candela source of light emits 4 π or 12.57 lumens, by definition. The illuminance is numerically the same either in lumens per square meter, or in foot-candles (obsolete unit).

With a photometer adjusted at the point of equal illuminance between two light sources, one a standard, the other "unkown", we have:

Equation .2: $\text{Illuminance}_s = \text{Illuminance}_x$

$$E_s = E_x$$

$$\frac{I_s}{r_s^2} = \frac{I_x}{r_x^2}$$

where the subscript (s) refers to the standard, and (x) refers to the "unknown" source.

The sensitive element that we will use instead of a photometer is a photovoltaic Cell, which generates an emf in proportion to the illuminance striking it. Its sensitive cesium surface is comparable to the human eye in color response. This is a delicate instrument. Never expose it to direct sunlight or other bright light — especially without a load connected to it.

Sample Laboratory Experiment (Invertebrate Zoology)

TITLE: HOMARUS AMERICANUS PART II

Purpose:

To become familiar with details of structure, physiology and some natural history relating to Homarus americanus.

Materials:

Dissecting kit, dissecting pan, dissecting microscope.

Procedure:

Note: Authorities are not in agreement on the segmentation: some do not regard either the preantennary or the telson as true segments, thus resulting in 19 segments; others recognize either the preantennary segment or the telson, resulting in 20 segments; still others recognize both the preantennary segment and telson, making 21 segments. For this lab., we will assume that the American lobster has 19 body segments (Storer and Usinger, 1957). The first appendage (antennule) is included whereas the telson is excluded.

A typical appendage of the higher crustaceans consists of not more than seven segments, including the basal coxa, which is followed by the basium bearing the endopodite of five segments. If the coxa and the basium are fused, the resulting structure is known as a protopodite. Appendages may be provided with epipodites or endites, i.e., processes arising from the coxa and the endopodite. In the lower crustaceans the leg has an exopodite as well as an endopodite, both of which arise from the basium. But in the higher crustaceans, such as Homarus americanus, approximately one-half of the appendages are missing the exopodite.

1). The first antenna (antennule) consists of a basal stalk of three segments and a pair of slender many-jointed distal flagella, the outer one being the longer. On the dorsal surface of the coxa, there is a small opening to the sac-like statocyst. Inside the sac are numerous sensory hairs and small statoliths, grains of sand first introduced through the opening during the fourth mysis or lobstering stage, which are shed and replaced with each succeeding molt. Open the statocyst and notice the sensory hairs and sand grains.

2). The second antenna consists of a coxa and a basium, the scalelike exopodite and the three-jointed endopodite with a many-jointed flagellum; ventrally on the coxa is the opening of the green gland.

3). Each mandible consists of two parts: a quadrate base, used in crushing food; and a three-jointed palpus representing the endopodite.

4). The first maxilla consists of a basal coxa and three lobes. The first lobe (first endite) is borne on a separate arm off the coxa. The other two lobes are borne on a second arm, which may be regarded as a basium carrying a distal second endite and a much reduced endopodite.

5). The second maxilla carries two long densely fringed endites, a slender tapering endopodite, and a long flat lateral epipodite, known as the scaphognathite or bailer. The first 5 pairs of appendages belong to the head.

6). The first maxilliped resembles the second maxilla in having a branched, fringed endite and a large coxal epipodite, but differs in having both an endopodite and an exopodite.

7). The second maxilliped consists of a two-jointed protopodite, a four-segmented endopodite, the exopodite with many-jointed flagellum, the epipodite and the rudimentary gill or podobranch. The first segment of the protopodite is the coxa, the second the bas-ischium; the first segment of the endopodite, the merus, carpus, propus, and dactylus. Endites are absent.

8). The third maxilliped consists of a two-segmented protopodite, a five-segmented endopodite, a small exopodite (both arising from the basium). Beginning proximally, the endopodite consists of ischium with combs, merus, carpus, propus and dactylus. The coxa bears an epipodite with a gill, the second podobranch.

9-13). The first pereiopod (chela) with the toothed claw shows also an epipodite and a podobranch. It has the same segmentation as the true walking legs, except for the union of the ischium with the basium. This fusion forms the "breaking joint". The chela consists of a greatly enlarged propus with a strong claw-like lateral extension which forms the "fixed finger", and the dactylus, which is articulated on the propus at the base of the fixed finger and constitutes the "movable finger". This appendage in the adult consists of six free segments or podomeres and as many free joints.

Examine the third pereiopod, locating all structures including epipodite, podobranch and, if the specimen is a female, the oviductal opening. The second and third pereiopods are also chelate.

Do the same with the fifth pereiopod. If the specimen is a male, observe the opening of the vas deferens.

14-19). The following six pairs of appendages belong to the abdomen and are called pleopods. The first pair is uniramous. In the female, it is quite small, in the male it is developed as a pair of stylets for copulation. The second, third, fourth and fifth pairs of pleopods are biramous and very much alike in structure. They consist of a single-segmented protopodite and flat exopodite and endopodite, both the latter fringed with tactile hairs. These pleopods are used for forward swimming and, in the female, for holding and aerating the eggs. The last pair of pleopods is at the same time the last pair of appendages. These pleopods, known as uropods, belong to the nineteenth segment and form together with the telson a powerful fan used in swimming. A uropod consists of a protopodite, a single-segmented endopodite, and a two-segmented exopodite; both of which are paddle-like and fringed with tactile hairs.

Sample Laboratory Experiment: (Field Biology)- (Ecology)

TITLE: PRIMARY PRODUCTIVITY

Introduction:

The primary productivity refers to the rate at which energy is stored by photosynthetic and chemosynthetic activity of producers in the form of organic substances which can be used as food.

Productivity may be measured by any one of several means. The most common method is by the measurement of oxygen output of the producers, primarily algae and other aquatic plants. The oxygen is used as an index of productivity.

The overall photosynthetic process is as follows;

$$6\ CO_2 + 6\ H_2O \text{ - - - - - - - - - } C_6H_{12}O_6 + 6\ O_2$$

For any study of productivity by oxygen determination it must be remembered that oxygen is only being produced during the lighted period and is being used at all times.

Equipment:

Nansen bottles, 3 - 250 ml. clear bottles with stoppers, opaqua black covers (or Aluminum Foil), Winkler apparatus.

Method:

1. Determine the oxygen content of water from the test location and depths. This is done by the "Winkler Method".

2. Take two bottles (250 cc) of water samples from the area and seal them.

3. One of the bottles is then covered with an opaque black cover to exclude all light. In the uncovered bottle, photosynthesis, and respiration will occur. In the covered bottle only respiration will occur. The water in these bottles should include photosynthetic organisms.

4. The bottles should then be placed in an area with sufficient light for normal growth. This is preferably the area from which the specimens were taken or an incubator set up to resemble the area.

5. At the end of a given time, at least four (4) hours, each of the bottles is analyzed for oxygen content. (By the Winkler Method).

6. Total oxygen production is the sum of the difference between the oxygen content at the start of the experiment and the oxygen content in each bottle at the end.

EXAMPLE:	Oxygen at the end, bottle uncovered	10.0 ppm O_2
	Oxygen at start	- 7.0 ppm O_2
	net oxygen produced	3.0 ppm O_2
	Oxygen at start	7.0 ppm O_2
	Oxygen at end, bottle covered	- 2.0 ppm O_2
	Oxygen consumed	5.0 ppm O_2
	Net oxygen produced	3.0 ppm O_2
	Oxygen consumed	+ 5.0 ppm O_2
	TOTAL OXYGEN PRODUCED	8.0 ppm O_2

Appendix "A": THE WINKLER METHOD

Introduction:

The standard method for the estimation of dissolved oxygen is the Winkler method, in which manganous hydroxide is allowed to react with the oxygen giving a tetravalent manganese compound; in the presence of acid potassium iodide, an equivalent quantity of iodine is liberated which is titrated with standard sodium thiosulfate.

Method:

1. Collect the specimens with a Nansen Bottle being sure not to trap any air bubbles. This is accomplished by running the rubber delivery tube into the bottom of the sample bottle. Allow the water to overflow while slowly withdrawing the tube.

2. Insert the glass stopper, being careful not to entrap air bubbles.

THE NEXT STEPS SHOULD BE CARRIED OUT IMMEDIATELY AFTER THE BOTTLES HAVE BEEN FILLED.

3. Introduce 1 ml of $MnSO_4$ solution, by inserting the tip of the pipette below the surface of the sample, and allowing the $MnSO_4$ to flow in slowly - the reagent will sink to the bottom of the bottle. Do not blow out the pipette.

4. In the same manner, introduce 1 ml of KOH-KI

5. Replace the stopper quickly, neglecting overflow, but carefully without trapping air bubbles and mix immediately and thoroughly by vigorous snapping motion of the wrist.

Allow the bottle to stand until most of the precipitate has settled. Mix thoroughly again and allow precipitate to resettle.

6. When the upper third of the bottle is perfectly clear (about $\frac{1}{2}$ hour) introduce 1 ml of concentrated H_2SO_4 in the same manner as above, replace the stopper and immediately mix as above, making sure that the precipitate is completely dissolved.

AT THIS POINT THE SAMPLE SHOULD NOT STAND TOO LONG. KEEP IT WELL STOPPERED AND IN THE DARK.

THE REMAINING STEPS ARE DONE IN THE LABORATORY.

Standardization:

The thiosulfate solution should be standardized against potassium bi-iodate before a series of determinations, or each time a new solution is prepared.

Titration:

1. Measure out accurately 50 ml of the sample and transfer it to a 125 ml flask. Volume of the titration flask is determined by sample size. Always use a flask large enough to provide good stirring action so that a sharp end point may be obtained.

2. Fill the buret to the zero mark. Be sure to flush out any old solution which has been standing in the burette before beginning the titration.

3. Run the thiosulfate solution with stirring until solution is almost clear, ie. a very pale straw yellow. Without stopping, add 3-4 drops of starch indicator. This will give a blue color to the solution. If starch is added before most of the iodine is titrated, the iodine will not be readily discharged from the starch at the end point giving erroneous results.

4. Continue adding thiosulfate solution with a finer stream until the solution is clear. Do not go drop-wise. Ignore color changes that occur after the end point has been reached.

5. Read the buret carefully and note.

6. The calculations for determination of oxygen content are complicated and will be described in detail in class by the instructor.

Sample Laboratory Experiment (Chemical Oceanography)

TITLE: THE DETERMINATION OF SALINITY BY THE KNUDSEN METHOD

Purpose:

To demonstrate procedure for preparing equipment and reagent solutions and familiarization with titrimetric procedure and end-point color for the Knudsen technique.

Schedule of Session:

1. Equipment
   a. Issuance
   b. Setting up the Knudsen apparatus
   c. Burette and pipette cleaning procedures

2. Reagents
   a. Preparation of the silver nitrate solution (each student)
   b. Preparation of the chromate indicator (instructor, demo)

3. Standardization
   a. Titration of the standard sea water w/student-prep $AgNO_3$
   b. Calculation of silver nitrate "strength" ("alpha" value)
   c. Adjustment of silver nitrate solution concentration

4. Sample titration
   a. Familiarization w/procedure and w/proper end-point color
   b. Proper use of the titration data sheet
   c. Calculation of chlorinity and salinity by use of the Knudsen Tables
   d. Titration of student unknowns (for grade)

5. Cleaning and Securing Glassware

Sample Laboratory Experiment (Microbiology)

TITLE: SPORE STAIN

Purpose:

To examine some old plates for feathery colonies of Bacillus cereus. Stain some material from the edge of a colony via the spore stain described below.

Solutions: a. 5% aqueous malachite green
b. 0.5% aqueous safranine

Procedure:

1. Prepare a smear of the desired organism to be stained. Dry the film and fix with heat.

2. Cover the smear with a piece of absorbant paper which does not reach to the edges of the slide.

3. Cover the slide with solution a. (malachite green). Heat the bottom of the slide with a burner flame so that water vapor rises from it without boiling. Continue heating intermittently for 4 - 5 minutes, but replenish the stain as it evaporates so that no drying occurs during the process.

4. After the slide has cooled to room temperature, wash it thoroughly with tap water.

5. Counterstain 30 - 60 seconds with solution b. (safranine), then wash and dry. Examine under oil immersion.

MATURE SPORES WILL BE STAINED GREEN, WHETHER FREE OR STILL IN THE VEGETATIVE SPORANGIUM: VEGETATIVE CELLS AND SPORANGIA WILL STAIN RED.

A. India Ink Capsule Outline: Capsules may be demonstrated by outlining them with India ink (negative stain).

Procedure:

1. Place a drop of safranine on a slide and emulsify in it a bit of growth of the designated organism. Add a drop of Pelikan India ink of equal or greater size, then mix.

2. Place a cover-slip on the mixture, cover with a piece of filter paper, than aluminum foil, and press so that both thick and thin areas are obtained. Discard foil and paper in the disinfectant jar.

3. Examine under oil immersion. The India ink can be clearly seen outlining the capsule.

Sample Laboratory Experiment (Physical and Geological Oceanography)

TITLE: FORAMINIFERA - COLLECTION AND IDENTIFICATION LABORATORY

Purpose:

To observe and identify local species of foraminifera, and to compare the foraminiferal populations with the characteristics of the sediment on which they are found.

Equipment:

1. Bottom grab
2. Corer
3. Plankton net
4. Rose bengal stain
5. Seives
6. Black metal picking trays
7. Fine brushes
8. Cardboard mounting slides
9. Water soluble glue
10. Metal mounts for slides
11. Glass slides

Method:

1. Collection - Specific sites for field collection of specimens to be determined by the individual instructor - as weather and time permit.

   However, efforts should be made to sample the following general locations:

   a. Deep water sediments
   b. Shallow water sediments
   c. Interdial sediments
      1. salt water
      2. brackish water
   d. Plankton sampling
      1. surface
      2. mid water
      3. bottom

   these should be taken at early morning, midday, and late afternoon.

Processing Bottom Sediments

2. Stain the samples with rose bengal stain to stain any living foraminifera.

   Wash the samples with tap water to remove the clay and other fine materials.

Carefully rinse the material collected on to a black metal picking tray and pour off the excess water.

Examine the residue under low power magnification.

Any foraminifera present may be picked up with a fine brush moistened in water and twirled to a fine point. The forams will stick to the brush and may be transferred to a cardboard mounting slide. Forams stained red were alive at the time of collection.

The forams on the slide may be glued down by dipping the brush in the special water-soluble glue. All of this work should be done under the microscope.

Attempt to identify the general features of the specimens by using the sheets handed out by the instructor.

Attempt to distinguish between the calcareous type and the arenaceous (cemented sand grains) type.

When finished, the cardboard-mounting slide may be placed into a metal mount and a glass slide placed over it.

3. Processing Core Samples

The outside of the core should first be scraped clean of possible contaminating material and a small segment scooped out. This is then washed through sieves, picked, and then identified.

4. Processing Plankton Samples

The major type of planktonic foram found in this area is Globigerina, the "tests" of which you may have found in the sediments. It is doubtful that any planktonic forams would be found alive close to the shore.

* Accurate drawings, fully labelled as to genus and species, and also noting collection site and magnification are required.

** Examine the prepared slides of several types of foraminifera which the instructor has set up under the microscope.

Sample Laboratory Experiment (Planktology)

TITLE: DETERMINATION OF THE ABUNDANCE AND DISTRIBUTION OF PLANKTON FROM A COLLECTED SAMPLE

Introduction:

It is important to know the kinds and number of planktonic organisms in the sample collected for a variety of reasons. The numbers of eggs and larvae are good indications of the future populations of adults of the same species. The abundance of certain kinds will determine the food available for fishes and other marine animals, and the types and quantities may also be good indicators of oceanographic phenomena.

Procedure:

Before any analysis is begun, the total volume of water strained must be determined. The following formula is used for this purpose:

$$V = \pi r^2 L$$

Where; V = Volume (in cubic meters)
π = 3.1417
r^2 = radius of net, squared (in square meters)
L = towing distance or length (in meters)

1. Numerical - It is difficult to count all organisms in the sample taken and so smaller subsamples are usually counted. Several types of subsampler are in use which include "Folsom splitter", "Cushing splitter", and "X-splitter" in the "Plankton Sorting Tray". All these samplers will be available to the students during this laboratory period.

2. Volumetric - Some idea of the volume may be obtained at sea by allowing the zooplankton to settle to the bottom of a graduated cylinder and reading the volume directly. A few drops of formalin will kill organisms and hasten the settling. A more accurate method is to determine the combined volume of plankton plus liquid; then filter off the plankton and measure the volume of difference between the two readings as the displacement volume of the plankton.

3. Gravimetric - A good estimate of the weight or mass of zooplankton is found by filtering, drying and weighing a portion, say, on-half of the plankton. This is best done inside a drying oven at 50° C.

Sample Laboratory Experiment (Microtechnique)

TITLE: BONE STAINING

Materials:

Ethanol, Formalin, Acetone, Ammonium Hydroxide or Potassium Hydroxide, Alizarine Red, Glycerine, Plastic, Specimen, six glass jars.

Procedure:

1. Skin the animal intended to be stained.
2. Remove viscera and all abdominal organs.
3. Fix specimen with either (70%-90%) ethanol or formalin. Leave specimen for approximately three days.
4. Soak specimen in acetone for 1 - 4 days to remove lipid material.
5. Resoak in ethanol (12 - 24 hours).
6. Clear the tissue by soaking it in a caustic solution. If specimen is a fish, clear with 1% ammonium hydroxide. Leave the fish in this solution until it's spinal cord is visible through the muscle. For animals other than fish, use 1% Potassium Hydroxide. Leave specimen in this clearing bath until the external bones are visible.
7. Stain. Use a 5% solution of Alizarine red in 95% ethanol. Transfer specimen back to a solution of either ammonium hydroxide or potassium hydroxide, and than add staining solution drop by drop until the bath is colored a pink color. If after 24 hours, the bones are not stained as darkly as should be, add a few more drops of staining solution to the bath. When bones are red enough, surplus stain washed out of other tissues with alkaline alcohol solution.
8. Transfer back to fresh ammonium or potassium hydroxide solu- overnight.
9. Substitute glycerine for water in tissues by gradually allowing water to diffuse out and glycerine to diffuse in. Glycerine functions as both a perservative and clearing agent.
10. Specimen can now be embedded in plastic. Wash off excess glycerine in acetone bath. Soak specimen in uncatalyzed plastic for a day. Transfer specimen to catalyzed plastic mold.

Sample Laboratory Experiment: (Marine Botany)

TITLE: MOUNTING SPECIMENS

Purpose:

To become familiar with a procedure used to permanently mount algal specimens.

Materials:

Marine algae is best preserved for taxonomic study as dried specimens. The basic equipment used for drying and mounting algal specimens consists of the following:

1. Medium weight herbarium paper. (standard sheets are 11.5" x 16.5")
2. Wax paper.
3. Herbarium blotters or folded newspaper.
4. Pans large enough to immerse the mounting paper.
5. Large camel's - hair brush.
6. Plant press.

Procedure:

1. Place enough water in pan to cover herbarium paper.
   Note: Marine specimens should be mounted in sea water whenever possible.
2. Herbarium paper placed in pan.
3. Chosen specimen washed to remove dirt and debris.
4. Specimen placed in pan on herbarium paper and roughly arranged.
5. If specimen is too thick, branches should be removed from inconspicuous places so that individual branches will show clearly when the plant is dried.
6. Next comes the final arrangement aided by brush or water from pipette.
7. Remove Herbarium paper with attached specimen from pan.
8. Drain water off paper.
9. Place blotter paper on plant press.
10. Place Herbarium paper with attached specimen on blotter.
11. Cover specimen with wax paper.
12. Tie plant press together.
13. Specimens dry fast when air is forced through the plant press with a fan.
14. When specimens dry, remove from plant press for subsequent classification.

Sample Laboratory Experiment (Fishery Science)

TITLE: THE SCALE METHOD OF AGE DETERMINATION

Introduction:

Fish scales, like other bony structures, show seasonal changes in rate of growth. This is particularly true in waters which become cold enough to interrupt growth for part of each year. Growth occurs both underneath and on the margins of the scales. Each addition to the margin is demarcated by a ridge (circulus) encircling the central zone (focus) of the scale. Seasonal cessation of growth or other factors may result in one or more discontinuous circuli located between two continuous ones. This is one of the criteria which identifies a year mark or annulus. Annuli may also be identified by a crowding of the circuli just inside the year mark, or by the presence of incomplete circuli.

Validity of annulus-like markings should not be assumed for species where their worth has not been proven. The worker should avoid being misled by "spawning checks", "false annuli", and other marks which may be due to any one of several causes such as resorption, interruption of growth by bodily injury, disease, or spawning.

Objective:

This laboratory exercise is designed to familiarize the student with the morphology of typical ctenoid and cycloid scales, with emphasis being placed on identification of true annuli or year marks.

Equipment and Materials:

Specimens of brook trout (Salvelinus fontinalis) and yellow perch (Perca flavescens,) a mild soap and water solution, dissecting kits, microscope slides, dissecting microscopes, and a microprojector are needed to complete this exercise.

Procedure:

1. In order to be comparable, scale samples must be removed from the same region of the body of each fish. Remove about 20 scales from a location just below the origin of the dorsal fin of a brook trout and a yellow perch. The scales may be scraped off with a knife or removed with forceps.

2. Scales may have mucous, epidermis, or other foreign material adhering to them. Taking care not to break the margin or mar the inner portion, clean the scales in water with a hard-bristled brush or a sharpened piece of wood.

3. Prepare a temporary scale mount by placing the cleaned scales in a drop of soap and water solution between two microscope slides. Some workers find that mounting the dry, cleaned scales between two slides is a satisfactory procedure with certain species.

4. Using a dissecting scope, microscope, and microprojector, examine several scales from each fish. Determine which viewing method best enables you to identify the circuli, annuli, and focus of each scale. Estimate the age of your specimen by counting the annuli on several scales.

5. Sketch and label the scale types encountered in this exercise.

Sample Examination in Elements of Oceanography

1. Name at least four different desciplines of oceanography studies.
2. Hydrologists are physical oceanographers who specialize in understanding water. T or F
3. Ecologists in oceanography study entire marine habitats in order to understand animal and plant populations, distributions and interdependencies. T or F
4. Match the left hand column with the right.

a) Benjamin Franklin	( ) Challenger expedition
b) Charles Darwin	( ) Water sampling bottle
c) 1872 - 1876	( ) Beagle
d) Mathew Fontaine Maury	( ) Gulf Stream
e) Fridtjot Nansen	( ) First textbook

5. Name four kinds of deposits for bottom sediments in the ocean.
6. Define, Salinity.
7. The epipelagic zone is also known as the photic zone. T or F
8. Name three factors that causes the increase in density of the surface water in the ocean.
9. With the increase in salinity and temperature, the sound velocity increases. T or F
10. What percent of the oceanic area is covered by the continental shelf?
    a) 7.5%
    b) 15%
    c) 30%
    d) 80%
11. The "inner core" of the earth is composed of 75% iron and 25% nickel. T or F
12. What evidence has been used to support the idea of continental drift? Name two such evidences.
13. The depth at the continental slope varies from
    a) 500 - 1000 fathoms
    b) 1500 - 3000 fathoms
    c) 3000 - 4000 fathoms
    d) 4000 - 6000 fathoms
14. What is the greatest depth of the ocean and where is it?
15. What causes the red tide?
    a) Runoff from land
    b) Change in temperature & salinity
    c) Planktonic organism
    d) Extreme high tide
16. How did "Black Sea" get its name?
17. What is the "Moho"?

18. Gyots are referred to the flat topped sea mounts. T or F
19. Pressure may be in pounds per square inch or dynes per square centimeters. T or F
20. Complete the following formulas.

S 0/00 = +1.805 Cl 0/00

Sample Examination in Instrumentation and Methods in Oceanography

True or False

_____1. The Phleger corer takes cores only 6' long.
_____2. The main factor causing the shortening of a core in the core tube is friction.
_____3. The Emery-Dietz corer takes cores up to about 30' long.
_____4. The Van Dorn bottle is of brass and plastic construction throughout.
_____5. The Kemmerer bottle is of brass construction.
_____6. Since brass won't corrode, tools made of this metal need no special care except when they break.
_____7. The basic principle involved with water samplers is that they are opened and closed at some depth, thus taking water from that depth.
_____8. The first sampling bottle designed was invented by Benjamin Franklin in 1769.
_____9. The biplane drag gives a reasonable estimation of surface current velocity.
_____10. The Nansen bottle has a capacity of 1250 ml.
_____11. The Nansen bottle has two clamping mechanisms to fasten it to the hydrowire.
_____12. When it is tripped, the Nansen bottle flips over a 90° arc.
_____13. The Cobet sampler is a large volume sampler.
_____14. The submersible pump is a nearly ideal tool for collecting plankton.
_____15. The Birge-Ekman plankton trap is named for the two men who developed it.
_____16. Silk bolting cloth is much used in plankton nets because it stands up well to repeated wettings.
_____17. One of the older types of plankton nets is the Hanson net.
_____18. The meter net has an opening of 0.1 square meter.
_____19. The Fjarlis bottle, like the Nansen bottle, has a thermometer frame and is a reversing bottle.
_____20. Flushing characteristics of the Frautschy bottle are poor.
_____21. The Braincon multiple water sampler will obtain up to 60 water samples per unit per lowsring by a programmed mechanism.
_____22. In high speed plankton samplers, the net area is large in relation to mouth opening to increase back pressure.
_____23. The Hardy High Speed Plankton Indicator is towed at 20 knots or better at the surface.
_____24. The Petersen grab has a simple foot-trip device which opens the jaws when the grab hits the bottom.
_____25. The Van Veen dredge has no foot-trip device.
_____26. A sampler in which a scoop rotates on an axle while a frame rests on the bottom is the Holms mud-sampler.
_____27. The orange-peel sampler has four jaws instead of the usual two.

_____28. The Dietz-LaFond sampler can sometimes sample rock.
_____29. The spring-loaded jaws of the Ekman dredge are held open by two light chains leading to the main release mechanism which is pressure activated.
_____30. The primary advantage of SCUBA as a tool in bottom sampling is the element of selectivity.

Sample Examination in Chemical Oceanography

I. SHORT ANSWER and FILL-IN: Make sure that each blank is filled.

1. If there are four separate phosphorus fractions present in sea water, how is each distinguished from the others?
2. The _____ method of suspended solids analysis is suitable for use in either fresh or salt waters.
3. Before the final reagent is added, a brownish precipitate in a D.O. sample indicates that some _____ is present.
4. Name the indicator solution needed in the following analyses:

oxygen_____	pH _____
salinity_____	turbidity_____
alkalinity_____	phosphorus_____

5. Name three mechanical methods of determining the composition of sediments by grain-size analysis.

II. PROBLEMS: Solve as directed. Show all of your calculations. Label with the proper terms. Do not use a slide rule. If you need certain tables, they will be available for use at the front desk.

1. C.F. = 0.995 buret reading = 9.27 volume titrated = 200 ml

   What is being analyzed for? _____
   How much of it (in proper terms) is present? _____

2. C.F. = 1.012 buret reading = 4.32 volume titrated = 100 ml

   What is being analyzed for? _____
   How much of it (in proper terms) is present? _____

3.

sample volume filtered	250 ml
wt. of crucible alone	29.5000 gm
wt. of crucible + ash	29.5005 gm
wt. of crucible + filter +sample	29.5937 gm
wt. of crucible + filter	29.5900 gm

   a) Calculate the weight (in mg/l of the total suspended solids. _____
   b) Calculate the weight (in mg/l of the organic suspended solids._____
   c) Calculate the weight (in mg/l of the inorganic suspended solids._____
   d) What is the name of the method being used here?_____

4. OL = 0.08 a = 19.17 k =_____

5. Taking the appropriate values from Problem 4 (above), calculate the chlorinity in 0/00. _____
6. Then, determine the salinity in 0/00 by using the Knudsen equation. Show all work, including the equation. (No credit if work is now shown).
7. A 25.0 gm sediment sample was found to have 10.0 gm of particles smaller than 0.06 mm.
   What percentage of this sample was composed of silt and clay particles? _____
   What percentage was composed of sand and larger particles? _____
8. Observed density = 1.0239 Calculate the salinity. _____
   Temperature = 10° C. (Show steps used.)
9. By use of an induction salinometer, properly calibrated, the conductivity ratio for a sample was determined to be 0.97872. The sample temperature at the time of analysis was 20° C.
   What is the salinity of the sample? _____
10. No credit, but please answer.

    Approximately how often have you referred to A Glossary of Ocean Science & Undersea Technology Terms (a book you bought as freshmen)?

    Never _____ 5 - 10 times _____

    1 - 5 times _____ over 10 times _____

Sample Examination in Physical and Geological Oceanography

MULTIPLE CHOICE: Place the letter of the correct answer in the space at the right.

1. The core is composed of a) a molten outer core of aluminum silicate, b) a molten outer core of iron-nickel alloy, c) a molten inner core of iron-nickel alloy, d) a molten inner core of aluminum silicate. 1._____

2. The term orogeny refers to a) fossil formation, b) sediment desposition, c) mountain building, d) none of these. 2._____

3. The formation of the rocky mountains marked the beginning of the a) Paleosoic era, b) Mesozoic era, c) Cenozoic era, d) Recent Epoch. 3._____

4. In the northern hemisphere, the north seeking end of a compass needle points a) up, b) down, c) level. 4._____

5. Lines of equal magnetic field intensity are a) isogonic, b) agonic, c) isoclinic, d) isodynamic. 5._____

6. A rock composed of calcium carbonate and formed from the shells of marine animals is a) shale, b) evaporites, c) limestone, d)sandstone. 6._____

7. The Gulf of Maine is an example of a) a marginal plateau, b) a epicontinental marginal sea, c) a submarine canyon, d) an abyssal plain. 7._____

8. The continental slope extends, at its deepest, down to depths of a) 150 m, b) 1500 meters, c) 3000 m, d) 6,000 m. 8._____

9. Turbidity currents are the cause of the formation of a) the mid-ocean ridge, b) marginal plateaus, c) epicontinental marginal seas, d) submarine canyons. 9._____

10. Calcium carbonate oozes are usually not found below a) 2,000 m, b) 5,000 m, c) 10,000 m, d) 1,000 m. 10._____

11. Beaches with a more gentle slope are found where there is a) coarse sand, b) fine sand. 11._____

FILL-IN:

1. The angle between the geographic meridian and the lines of force shown by the compass is called the _____.

2. Two common magnetic minerals used to determine magnetic fluctuations are _____ and _____.

3. The continental shelf extends, on the average, to depths of _____ meters.

4. The entire length of the mid-ocean ridge system is about _____ miles.

5. When waves rush over an area and trap and confine air in the sand we see the formation of _____.

6. Small channels caused by the seaward rush of water that has been stored in the beach at high tide are called? _____

7. Beaches on the east coast of the U.S. are light in color and are composed mainly of the minerals _____ and _____.

8. Beaches on the coasts of Washington and Oregon are flat, hard and dark green in color and are composed mainly of _____.

9. A shoreline which forms where normal faulting has dropped a crustal block down so that it is completely submerged is called a _____ _____ shoreline.

10. Embayed coasts produced by the partial submergence of a fluvially eroded land mass are called _____ shorelines.

11. An elongated hill of glacial till along a shore such as in Boston Bay is called a _____ shoreline.

12. Due to the narrowness of a tidal inlet in a lagoon a _____ _____ is produced at each high and low tide.

EXAMINATION ESSAY SECTION:

I. Discuss fully three facts which tend to verify the theory of "Continental Drift".

II. Describe the two types of ripples.

SOURCES OF SOME AUDIOVISUAL MATERIALS

Association Films, Inc.
490 King Street
Littleton, Mass. 01460

Audio-Visual Services
Bureau of Commercial Fisheries
1815 North Fort Myer Drive
Arlington, Virginia 22209

Bell Systems
Local Representative or
Affiliated Companies

Capital Film Laboratories, Inc.
1905 Fairview Avenue, N. E.
Washington, D. C. 20002

Encyclopedia Brittanica Film, Inc.
1150 Wilmette Avenue
Wilmette, Ill. 60091

Eye Gate House, Inc.
146-01 Archer Avenue
Jamaica, N. Y. 11435

Filmtronics Lab., Inc.
231 W. 54th Street
New York, N. Y. 10019

Films on Oceanography
Publication C-4, 1966
National Oceanographic Data Center,
Washington, D. C. 20390

Imperial Film Company, Inc.
321 S. Florida Avenue
Lakeland, Florida 33801

International Film Bureau
332 S. Michigan Avenue
Chicago, Illinois

Life Education Program
Box 834, Radio City Post Office
New York, N. Y. 10019

Naval District
Code 08R
495 Summer Street
Boston, Massachusetts 02210

Row, Peterson Textfilms
Harper & Row, Publishers, Inc.
49 East 33rd Street
New York, N. Y. 10016

Shell Film Library
450 No. Meridian Street
Indianapolis, Indiana 46204

McGraw-Hill Text Films
330 West 42nd Street
New York, N.Y. 10018

SOURCES OF SOME SCIENTIFIC AND TECHNICAL PUBLICATIONS

The following list may be of interest to instructors and students involved in Applied Marine Biology and Oceanography Program:

Bulletin of Marine Ecology
Bulletin of Marine Science
Bulletin of the Scripps Institution of Oceanography
Biological Bulletin, Woods Hole Oceanographic Institute
Commercial Fisheries Review
Deep Sea Research and Oceanographic Abstracts
Ecology
Fishing News International
Hydrobiologia
Hydrospace
Journal du Conseil
Journal of Ecology
Journal of Experimental Marine Biology
Journal of the Fisheries Research Board of Canada
Journal of Marine Research
Limnology and Oceanography
Marine Biology
Marine Technology Society Journal
Maritimes
Monograph on Oceanographic Methodology
Nature
Ocean Engineering
Ocean Industry
Oceanology International
Oceananus
Offshore
Proces - Verbaux of the International Association of Physical Oceanography
Science
Scientific American
Sea Frontiers
Seahorse
Transaction of the American Fisheries Society
Undersea Technology
Underwater Science and Technology Journal
World Fishing

List of Faculty Members Affiliated with the Department of Applied Marine Biology and Oceanography at S.M.V.T.I.

Name	Subject
Acheson, Richard D. - Instructor M.S., University of New Hampshire; B.A., University of Maine	Microbiology
Baillargeon, Roland - Instructor B.S., University of Maine; M.S., Gorham State College	Mathematics
L. ierjee, Tapan - Coordinator B.S., University of Calcutta; M.S., University of the Pacific	Marine Biology - Oceanography
Caswell, Mrs. Frances P. - Instructor B.A., University of Maine; M.A., University of Michigan	English
Cobb, Elmer W. - Instructor B.S., University of Maine	English
Colpitts, Lawrence H. - Captain B.S., Gorham Teachers College Unlimited Masters License	Marine Science
Doughty, Aftin L. - Assistant Engineer Coast Guard License	Marine Science
Eayrs, Weston III - Instructor B.S., University of Massachusetts	Oceanography
Goode, Robert E. - Instructor B.A., University of Maine M.S., University of Maine	Marine Biology
Hupper, George W. - Instructor U.S. Navy Institute; U.S. Coast Guard Institute	Marine Science
Knowles, Dennis T. - Instructor B.S., University of Maine	Chemistry
Lomoriello, Luigi S. - Mate B.S., Maine Maritime Academy	Marine Science
Marcotte, Roland G. - Chairman, Science Department B.S., Bates College	Physics
Morong, Frank S. - Instructor B.S., Gorham State College M.S., Gorham State College	Political Science-Sociology
Siegel, Robert E. - Instructor B.S., Brooklyn College M.A., Hofstra University	Oceanography
Turner, Norman W. - Chief Engineer of the Vessels	Marine Science

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American Meterological Society

1965. Collected Bibliographies on Physical Oceanography

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Banerjee, Tapan.

1969. Marine Science Technology Program at Southern Maine Vocational Technical Institute. SMVTI., So. Portland, Maine. (Sea Grant Project #GH-35.)

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1969. Curriculum Outline for Elementary and Secondary Schools in Oceanography and Marine Biology. Oceanogr. Unliminted, Inc., Lodi, N. J.

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1967. A Selected Bibliography of Oceanography Books Published Between 1959 and 1966. Oceanic Library and Information Center, La Jolla, California.

Taber, R. W.; Leon R. LaPorte, and Ellsworth C. Smith.

1968. An Oceanographic Curriculum for High Schools Outline. U. S. Naval Oceanogr. Office., Wash.,D.C.

PHOTOGRAPHS OF LABORATORY AND FIELD ACTIVITIES

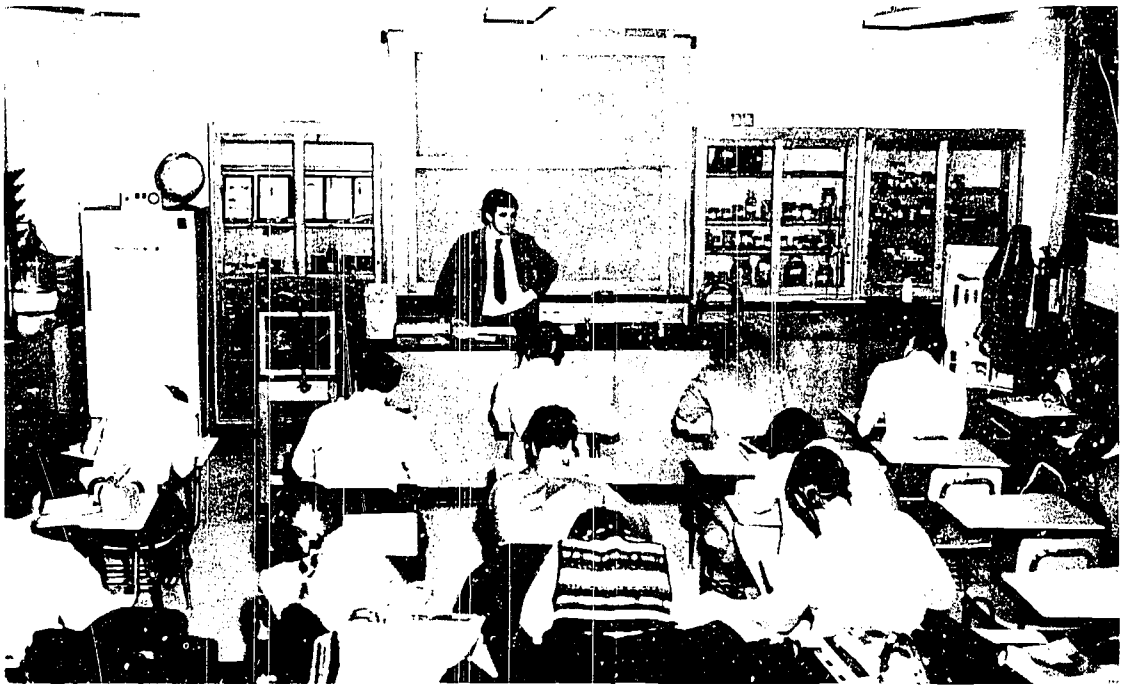

Figure 1. View of a typical marine biology class

Figure 2. Students preparing tissue for mounting on slide in histology laboratory.

Figure 3. Students sorting specimens from the box dredge haul for laboratory identification.

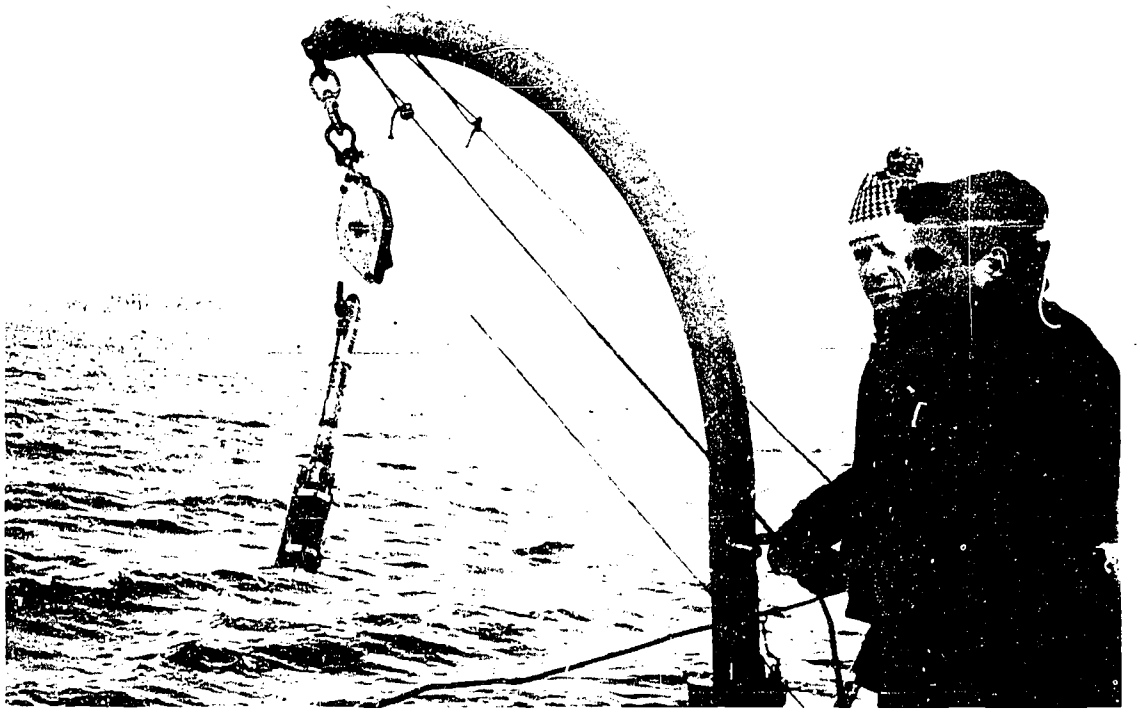

Figure 4. Technicians lowering the bathythermograph for temperature profile studies.

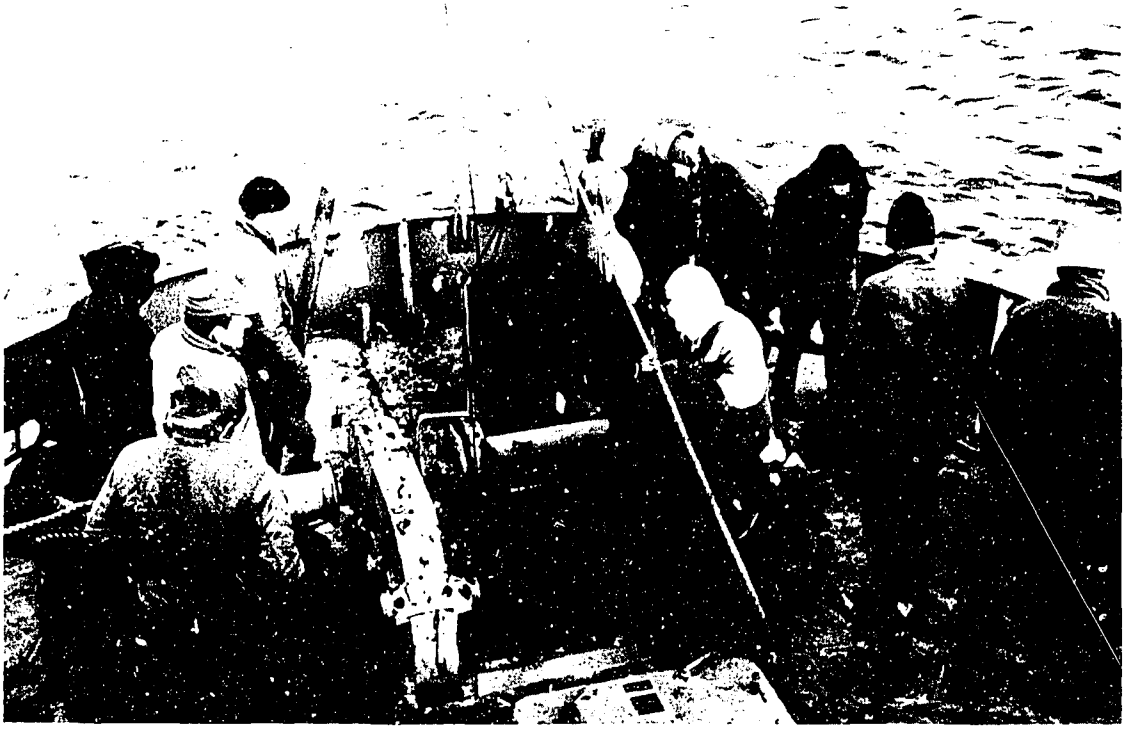

Figure 5. Students and Staff preparing to lower the box dredge for bottom sampling.

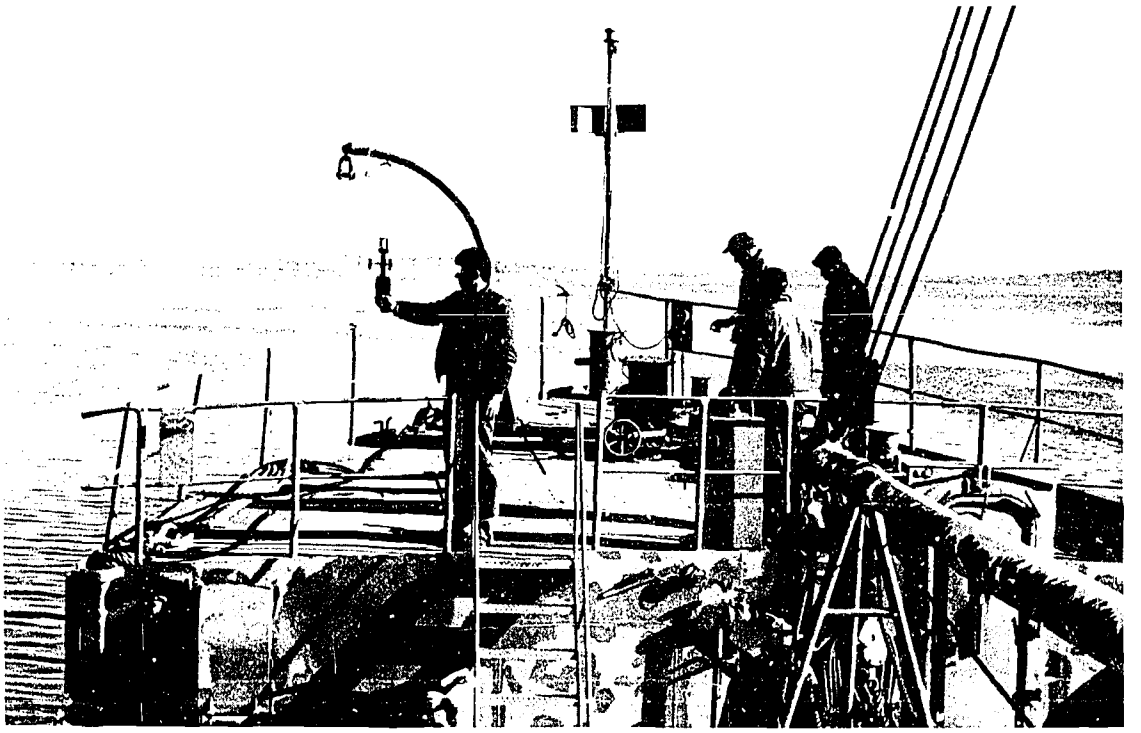

Figure 6. Technicians measuring wind speed and velocity on station.

Figure 7. Students and Instructor examining marine worms in the Invertebrate Zoology class.

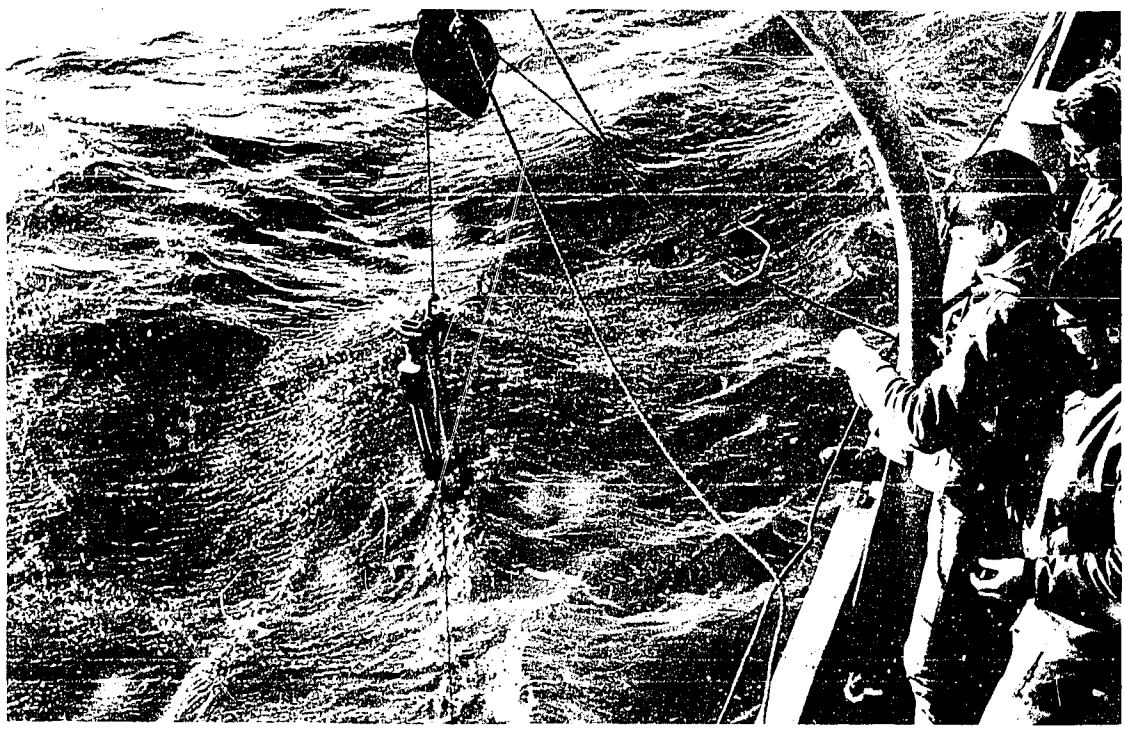

Figure 8. Students raising a Nansen bottle for water sample analysis.

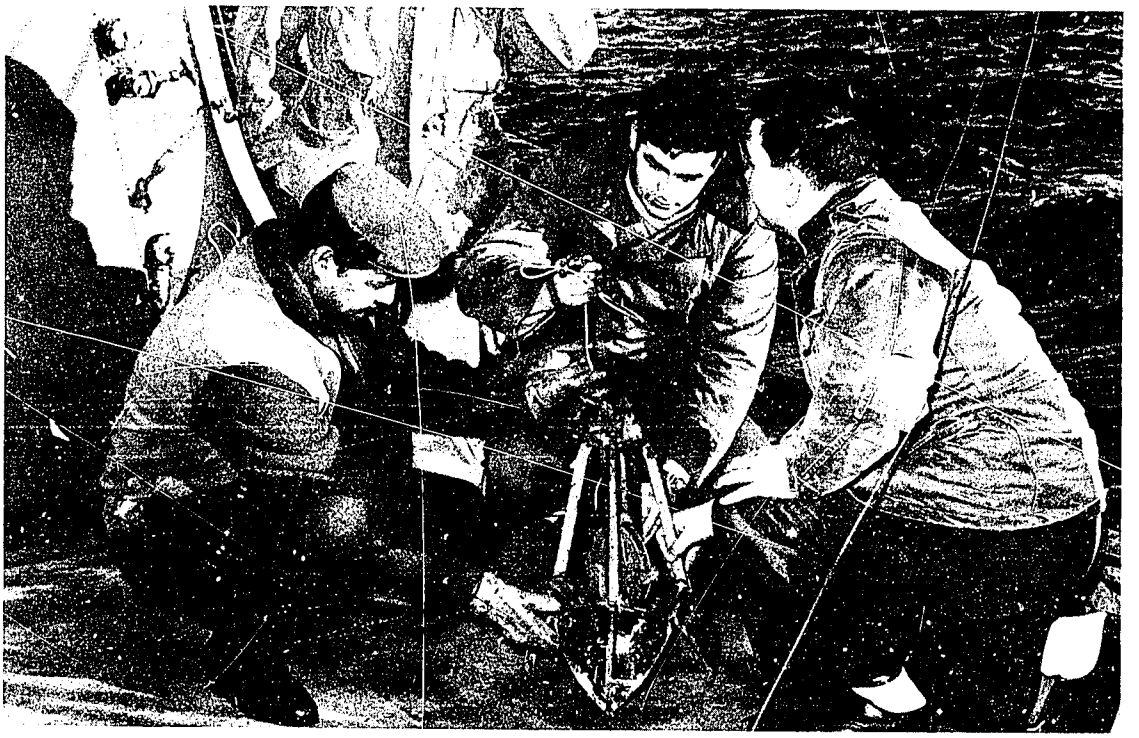

Figure 9. Students and Instructors getting ready to cast the bottom sampler "Orange Peel".

Figure 10. Students performing a gill net cast with the help of the Instructor (Center).